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Three Fertiliser Experiments With Potatoes.

L. J. H. TEAKLE* and E. T. MORGAN.†

SUMMARY.

1. Three fertiliser experiments with potatoes using the factorial design are described. Two were located in the Albany district and one at Waroona, Western Australia.

2. On virgin peat soil there was an outstanding response to superphosphate. Eight cwts. per acre appeared adequate.

3. On old potato land at Grasmere, Albany, 4 cwts. of superphosphate per acre gave optimal yield. At Waroona the best yields were obtained with 16 cwts. of superphosphate per acre.

4. From 1 to 2 cwts. of sulphate of ammonia per acre gave improved yields. At Waroona superphosphate was necessary for a response to sulphate of ammonia.

5. Potash gave little or no improvement in yield at Many Peaks and Waroona. At Grasmere up to 2 cwts. of sulphate of potash per acre appeared beneficial.

6. The principles of the factorial design for fertiliser experiments are discussed.

A. INTRODUCTION.

Since 1922 the Department of Agriculture has been conducting experiments to obtain reliable information which will be useful for the recommendation of fertiliser treatments for the potato crop. The earlier results have been published in this Journal and, in conjunction with the data here reported, have been summarised in a recent paper. (See this Journal, Vol. 19, No. 3, Sept., 1942.)

This paper is planned to give the results of the three most recent experiments with potato fertilisers. These were of complex design and two were carried out in the Albany district and one at Waroona. In the layout adopted for these experiments the old plan of comparing a small number of mixtures and rates of application was abandoned. More complete information can be obtained by studying the effects of all possible combinations of several rates of application of the ingredients in question. In this case, sulphate of ammonia, superphosphate, and sulphate of potash were the ingredients used. In the two experiments in the Albany district, four rates of application were used. This involves $4 \times 4 \times 4 = 64$ possible combinations and in consequence each block consisted of 64 plots each receiving one of the 64 distinct combinations. This layout is known as the "factorial design." Three replications were adopted so each experiment involved 192 separate plots.

*Plant Nutrition Officer. †Officer in Charge, Potato Branch.

The Waroona experiment involved three rates of application of sulphate of ammonia and sulphate of potash and four of superphosphate, giving a total of 36 possible combinations. With the threefold replication 108 plots were involved in the experiment.

Special mathematical examination of the results shows the straight-out effect of each fertiliser at each rate of application and of the effect of adding other fertiliser ingredients to each one of the fertilisers used. This second effect is known as "interaction."

The magnitude of the response to any one ingredient or treatment, for instance, superphosphate, is frequently affected by the addition of a second ingredient or treatment, for instance, sulphate of ammonia. This is known as a "first order interaction" and may be positive—when the addition of the second ingredient increases the response to the first ingredient—or negative when the response is decreased. It may be added further that occasionally the response to one ingredient or treatment is affected by the addition of a combination of other ingredients or treatments. These are known as "higher order interactions" but are seldom observed.

In experimental work it cannot be expected that two plots side by side and receiving identical treatments will give the same yield except in rare instances. If the conditions under which the experiment is being carried out are satisfactory, these differences which arise owing to soil variability and to numerous other factors which cannot be controlled in field experiments, will be small. Nevertheless, this natural variability must be recognised and carefully allowed for in considering the significance of differences between plots receiving different treatments. If the experiment is properly designed the extent of this natural variability can be calculated. When this is known the significance of the differences between the yields of plots receiving different treatments can be assessed by comparison with the differences which could be expected to arise due to natural causes outside the control of the experimenter. For this reason, the observed differences between different treatments, substantial though they may seem in many instances of experiments reported, cannot be accepted as proof of real differences unless they pass the test based on the natural variations operating under each set of experimental conditions. With each average yield reported in these papers the amount deemed necessary to indicate the existence of a real difference as a result of the experimental work, is given. It is termed "difference for significance" and is expressed in terms of tons of potatoes per acre.

Farmers may object that, in many instances, increases in yield associated with certain treatments which do not pass this test for significance would, if real, be highly profitable and warrant any extra expense involved. This must be admitted and no objections can be raised if the farmer decides to risk being extravagant when ample fertilisers are available. It would be unsound and unwise, however, to recommend high fertiliser dressings when a considerable number of experiments prove that moderate amounts are as effective over a wide range of conditions.

B. THE EXPERIMENTS.

1. *Mr. B. H. Burvill's property, Location* 3103, *Grasmere, Albany.*

The experiment was carried out on a reclaimed swamp which had been under potatoes each year since 1910 with the exception of two seasons. The soil is a grey diatomaceous earth and had been generously fertilised with each of the previous crops. The average dressing would probably approximate at least

10 cwts. of mixed fertiliser per acre. Yields have been good and the fertility seems well maintained in spite of the succession of potato crops. Micro-element deficiency does not appear to be a factor on this swamp (Teakle and Morgan, 1914).

The swamp is under water during much of the winter but grows a mat of Yorkshire Fog and some white clover. This is ploughed in as a green manure as soon as the land is drained in the spring and is thoroughly cultivated prior to the planting of the potato crops, usually in October.

This experiment was planted in November, 1939. The season was late and some difficulty was experienced in breaking down the sods and preparing a tilth for the planting. However, the crop went in under fair conditions and made satisfactory growth. During the growing period no very consistent differences were noted except that the plots receiving no nitrogen were a paler green than the others. It was also observed that 16 plots, not included in the experimental design but planted without fertiliser in the experimental area, made substantially the same growth as the adjoining fertilised plots, but were characterised by a paleness of the foliage apparently due to nitrogen not being up to luxury level.

The yields expressed as tons of total tubers per acre under the different treatments are given in Table 1.

TABLE 1.

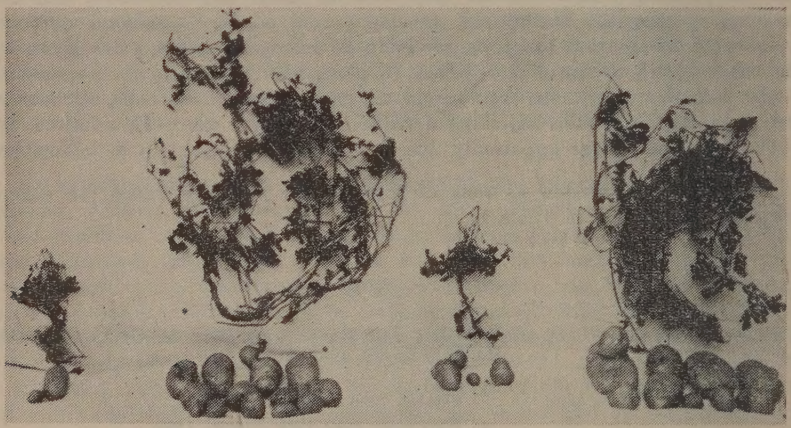
YIELD OF POTATO FROM DIFFERENT FERTILISER LEVELS AT GRASMERE AND MANY PEAKS, 1939–40.

Grasmere ... Planted 24th November, 1939.
Harvested 15th–19th March, 1940.
Many Peaks ... Planted 30th November, 1st and 2nd December, 1939.
Harvested 27th, 28th, and 29th March, 1940.

Fertiliser.	Level of Application (cwts. per acre).	Yield Total Tubers (tons per acre).	
		Grasmere.	Many Peaks.
	cwts.	tons.	tons.
None	...	7·4	1·6
Sulphate of Ammonia (20·5% N)	none	8·5	9·5
	1	9·5	10·8
	2	9·4	11·4
	4	10·0	11·1
Superphosphate (23% P_2O_5)	4	9·3	9·7
	8	9·3	10·8
	12	9·9	11·2
	16	9·0	11·1
Sulphate of Potash (48·5% K_2O)	0	8·7	10·3
	1	9·2	10·9
	2	9·9	10·8
	4	9·6	10·9
Difference for Significance	P = ·05	0·6	0·64

2. *Many Peaks Experiment.*

This experiment was carried out in association with Mr. B. H. Burvill's cropping programme on Messrs. J. Norman & Sons' property, Many Peaks, which lies near the coast about 30 miles east of Albany. On it are some 200 acres of valuable peat marsh which has been drained sufficiently for summer cropping in many parts. The portion selected for the experiment was in the virgin state. It adjoined and resembled that used for the micro-element experiment conducted in the same year, the results of which have been reported by Teakle, Morgan, and Turton (1941). No response to micro-element treatment was observed.



Small potato plants represent growth with no fertiliser at Many Peaks. The large plants were from an adjacent row receiving 4 cwts. sulphate of ammonia and 8 cwts. superphosphate per acre.

As described in the earlier paper the surface peat is blackish-brown to brownish-black in colour and fibrous in nature. The surface is quite strongly acidic in reaction (pH 3.96) but the acidity decreases with depth. The lower layers are brown in colour and are soft in consistency due to water logging. The mineral bottom is several feet below the surface. The chemical properties of the peat at the experimental area are represented by the figures given in Table A in the Appendix.

At the time of planting the soil was wet and soggy at a depth of 8 to 9 inches, but was sufficiently firm for preparation with the rotary hoe. Rapid drying-out took place during the dry summer period. At the time of harvesting the water table had disappeared and the peat immediately below the surface had cracked to a depth of two or three feet. Cracks up to six inches wide had formed, and commonly ran the length of the rows where water absorption by the growing crop had created lines of weakness.

Very little work was necessary to prepare the land for planting. After cutting and burning the rushes, the soil was cultivated once with the rotary hoe, which opened up a planting furrow. The "seed" and fertiliser were distributed in this furrow and covered by hand.

Throughout the growing period little difference in growth could be observed in the experimental plots. The foliage was not heavy but was healthy, and secondary growth occurred on the tubers, apparently due to the season and soil conditions as no relation to fertiliser treatment could be observed.

Five plots in the experimental area, but not included in the design, were planted without fertiliser. The "seed" on these plots germinated normally but made very little growth. At the time of harvesting, these plots resembled unplanted land. Only a small amount of small round tubers were produced by most plants maturing. Figure 1 illustrates the growth of the tubers without fertiliser in comparison with well fertilised plots adjacent. The yield results are given in Table 1.

Consideration of Table 1 giving the data from the two experiments in the Albany district, shows the great difference in behaviour of the old land well fertilised for nearly 30 years and the virgin peat.

The yield of potatoes with no fertiliser on the old potato land at Grasmere was 7.4 tons per acre, almost 80 per cent. of the average for the fertilised plots—9.4 tons per acre. On the virgin peat at Many Peaks without fertiliser, the total yield was only 1.6 tons per acre and half of the tubers by weight were too small for market. The yield without fertiliser is only 15 per cent. of the average yield of 10.7 tons per acre from the fertilised area. This difference is due chiefly to superphosphate. The three plots receiving 4 cwts. of superphosphate per acre alone gave an average yield of 9.5 tons per acre, only 1.2 tons per acre less than the general average.

The results of the two experiments indicate that 4 cwts. of superphosphate per acre would be adequate on the old land and up to 8 cwts. per acre on the new land.

On the old Grasmere land the evidence shows that an advantage is to be gained from the use of sulphate of ammonia, to the extent of about 1 cwt. per acre and of sulphate of potash, apparently to the extent of 1½ to 2 cwts. per acre.

At Many Peaks on the virgin peat, sulphate of ammonia was beneficial when used in small amounts of the order of magnitude of 1 cwt. per acre, but no significant benefit resulted from the use of sulphate of potash.

No interaction between the fertilisers was observed.

3. *Waroona Experiment.*—Through the courtesy and assistance of Mr. J. Salerian of Waroona, a similar experiment was carried out under irrigation in the 1941-42 season. Plans had been made for the experiment to be planted in November, 1940, but the shortage of irrigation water in that year necessitated postponement.

The site selected had been under pasture, consisting of Wimmera Rye Grass and Subterranean Clover, for a period of nine years (1932-40), and during this period had received superphosphate at the rate of two bags (373 lbs.) per acre per annum. This quantity was applied in two equal separate dressings in autumn and spring of each year. During the nine-year period dairy cattle were grazed on the land and for four years (1935-39 inclusive) the growth was cut and harvested for hay.

The experiment was planted on the 17th and 18th of December, 1941, and harvested on the 14th and 15th of April, 1942.

The growth proved a disappointment. Weed infestation was bad and, in addition, the crops had been attacked by the Potato Moth (*Phthorimaea operculella*) with the result that parts had withered off prematurely while in others the tops

had more or less recovered and were still green. The yields were very poor. There were many misses in the rows and it was decided that the most reliable index of yield would be obtained by considering the average yield from plants maturing in each plot rather than the average yield per plot as harvested. At planting, each plot had consisted of 39 sets so that it was possible to make a count of the misses when the digging was in progress. It is realised that there are serious objections to this method of assessment and for that reason the results must be treated with some caution. No other technique presented itself for the evaluation of the results and the only alternative was to discard the work. With the reservation mentioned it is considered that some guidance is offered by the results reported in Table 2.

TABLE 2.

YIELD OF POTATOES FROM DIFFERENT FERTILISER APPLICATIONS ON MR. J. SALERIAN'S PROPERTY, WAROONA, 1941–42.

Planted 17-18th Dec., 1941.
Harvested 14-15th April, 1942.

Fertiliser.	Level of Application.	Yield of Total Tubers.	Difference for Significance, P = ·05.
	cwts. per acre.	tons per acre.	tons per acre.
Sulphate of Ammonia (20·5% N)	none	4·0	0·72
	1½	5·2	
	3	4·6	
Superphosphate (23% P_2O_5)	none	2·9	0·82
	4	4·3	
	8	5·0	
	16	6·2	
Sulphate of Potash (48·6% K_2O)	none	4·3	Difference not significant
	1	4·5	
	2	4·9	

TABLE 3.

INTERACTIONS—THE EFFECT OF COMBINATIONS OF SULPHATE OF AMMONIA AND SUPERPHOSPHATE ON THE YIELD OF POTATOES ON MR. J. SALERIAN'S PROPERTY, WAROONA, 1941–42.

Nitrogen.	Phosphate.			
	0.	4.	8.	16.
0	2·7	4·6	4·1	4·6
1½	2·8	4·9	5·8	7·2
3	3·3	3·5	5·2	6·7

Difference for Significance P = ·05 = 1·44 tons per acre.
P = ·01 = 1·93 tons per acre.

TABLE 4.

INTERACTIONS—THE EFFECT OF COMBINATIONS OF SUPERPHOSPHATE AND SULPHATE OF POTASH ON THE YIELD OF POTATOES ON MR. J. SALERIAN'S PROPERTY, WAROONA, 1941–42.

Potash.	Phosphate.			
	0.	4.	8.	16.
0	2·6	3·9	4·4	6·4
1	3·2	4·5	4·1	6·5
2	2·9	4·6	6·6	5·6

Difference for Significance P = ·05 = 1·44 tons per acre.
P = ·01 = 1·93 tons per acre.

The results indicate that there is a substantial advantage from the use of superphosphate. Taken at their face value there is indication that increased yields are obtained from the use of considerable amounts of superphosphate per acre, as 16 cwts. per acre gave a significantly better yield than 8 cwts. However, on account of outside factors interfering with the growth, the experiment cannot be regarded as conclusive as to the best amount for these conditions.

Sulphate of ammonia at the rate of 1½ cwts. per acre appears beneficial but the 3 cwts. per acre dressing did not produce an effect significantly better than none. This unexpected effect indicates that outside factors seriously interfered with the accuracy of the experimental results. The addition of potash had no straight-out effect on yield.

C. DISCUSSION.

The results of these experiments can be discussed together, although they represent widely different conditions, and due allowance must be made for the fact that the data from the Waroona area are not very satisfactory.

In general, under these conditions, it seems that moderate amounts of fertiliser are adequate to give satisfactory crops. Even on the highly phosphate-deficient virgin peat on Many Peaks no significant advantage was obtained from the use of more than 8 cwts. of superphosphate per acre.

No more than small applications of sulphate of ammonia and sulphate of potash appear necessary. In fact, sulphate of potash gave no significant yield increase at either Many Peaks or Waroona.

It may be asked whether potash may not have been necessary for keeping quality at these places, even if yield differences were not observed. No observations were made on material from the Grasmere and Waroona experiments, but samples of potatoes from Many Peaks were stored for six months to obtain information regarding tubers produced on plots receiving 0, 1, 2, and 4 cwts. of sulphate of potash per acre. It is of interest that at the end of the six months period the tubers from the no-potash plots were all sound, of a nice, bright golden colour and generally more attractive in appearance than the parcels from the potash plots. These tubers were less bright in colour and several showed signs of breakdown.

Potatoes are heavy absorbers of potash and, for that reason, potash, if available, should be included in the fertiliser mixture to the extent of 1 to 2 cwts. per acre for maintenance purposes. However, it seems that in periods of emergency there will be little or no deterioration in yield or quality under conditions represented by these experiments if potash is not used for short periods.

APPENDIX.

Chemical Examination of the peat soil from Many Peaks.

In order to obtain information regarding the chemical properties of the valuable peat formation, type samples to a depth of 3½ feet were obtained at a site in the virgin rush country adjacent to the experimental area.

The results are given in Table A.

TABLE A.

CHEMICAL PROPERTIES OF PEAT REPRESENTING THE MANY PEAKS MARSH.

General Chemical Properties.

Sample	3315	3316	3317
Depth (inches)	0–6	6–20	20–42
Loss on ignition	84·3 %	92·4 %	92·5 %
Organic Carbon, C	48·1 %	53·4 %	52·2 %
Nitrogen, N	2·54 %	2·31 %	2·14 %
Lime CaO	·95 %	1·03 %	1·03 %
Potash, K_2O	·046%	·016%	·036%
Phosphoric Acid, P_2O_5	·054%	·022%	·020%
Sulphate, SO_4	·91 %	·71 %	·59 %
Reaction, pH, (Quinhydrone)	3·96	4·31	5·02
Total Water Soluble Salts	·956%	·676%	·556%
Salt, NaCl	·223%	·145%	·186%
C : N ratio	18·9	23·1	24·4

Replaceable Cations (milli-equivalents per 100 grams).

Sample	3315	3316	3317
Depth (inches)	0–6	6–20	20–24
Calcium	26·8	30·1	32·0
Magnesium	22·1	32·0	38·2
Potassium	·55	·26	·49
Sodium	2·65	2·8	5·36
Total	52·1	65·2	76·3
	Per cent. of total.		
Calcium	52	46	42
Magnesium	42	49	50
Potassium	1	Trace	1
Sodium	5	5	7

Lime Requirement—Lime (CaO) tons per acre foot (1,750,000 lbs.).

pH5	pH6	pH7
8·4	16·8	27·4

Analysts—B. L. Southern, A. G. Turton.

The acidity of this soil is high. The reaction of pH 3.96 for the surface soil is about the minimum for satisfactory growth of potatoes and would indicate conditions too acid for crops such as cauliflower, peas, and beans, which are less tolerant of acid conditions. For these crops liming may be beneficial and an experiment would give interesting results.

It is fortunate that the formation does not contain sulphides* such as the mineral marcasite, as these compounds are readily oxidised to form sulphuric acid and other plant poisons which may accumulate in very harmful amounts.

It seems probable that the acidity in this peat is not likely to be increased with time to a damaging extent as in certain other swamp and marsh soils of the south coast. The use of lime sand from the coastal sand hills is an effective and cheap remedy in such cases of acidifiation, or "mineralisation" as it is commonly called.

REFERENCE.

1941: Teakle, L. J. H., Morgan, E. T., and Turton, A. G. Experiments with Microelements for the Growth of Crops in Western Australia. III Experiments with Potatoes, Vegetables and Other Crops in the Albany District. Jour. Agric., W.A., 18 (2), 1941, 96-125.

* Report by Mr. C. R. Le Mesurier, Government Chemical Laboratory.

Footrot in Sheep.

Its eradication from the Flock at the Chapman Research Station.

N. DAVENPORT—Agricultural Adviser.
F. GISHUBL—Manager, Chapman Research Station.

Until recently it was generally accepted that once an outbreak of true footrot in sheep occurred on a property, then the soil became contaminated with the casual agency and that it was then impossible to eliminate it. It was believed also that sheep depastured on such country were always liable to develop the disease under favourable seasonal conditions. These long accepted views have now been disproven by the work of Dr. W. I. B. Beveridge of the C.S.I.R. The results of his investigations were published last year in Bulletin No. 140 of the Council, entitled "Footrot in Sheep: a transmissable disease due to infection with Fusiformis nodosus (n. sp.)." It has been shown that the disease is caused by a specific organism and that if that organism is not present, then the sheep will not contract the disease, and further that the organism can only survive for a very brief period away from the sheep's feet. Fourteen days spelling of pastures is considered an effective period at any time of the year to rid them of the infective agent.

The information contained in this bulletin was made available to farmers in a condensed form in the June, 1941 issue of this Journal by L. W. Mehaffey, Assistant Veterinary Pathologist of this Department, and reprinted in leaflet form No. 668.

A system of eradication has been outlined, based on Beveridge's findings involving the removal and isolation of affected sheep and "carriers," and only placing "clean" sheep in clean paddocks which have carried no sheep for a fortnight. This will enable the careful sheep farmer to remove the disease completely from his flock for all time unless fresh infection is brought in.

As the investigation has so recently been brought to a successful conclusion of such great economic importance, it is thought that farmers may be interested in the successful application of the recommended procedure in eradicating the disease from sheep at the Chapman Research Station.

It is unfortunate that no pathological examination was made of diseased feet from affected sheep, in order to isolate the bacterium Fusiformis nodosus (n. sp.) and hence confirm the clinical diagnosis of true contagious footrot. However, the symptoms and course of the complaint were similar in all respects to those described by Beveridge. When conditions became suitable and an outbreak occurred, infection spread very quickly indeed.

Footrot, exactly similar to that which occurred on the Chapman Research Station, occurs elsewhere in the Victoria district. One of us (N.D.) has followed the course of the disease on a number of properties and has examined many of the affected sheep. In order to further substantiate the diagnosis of that at the Chapman Research Station, an affected sheep from a private property, and typical of those affected at the station, was recently forwarded to the Chief Veterinary Surgeon for examination. The Assistant Veterinary Pathologist reported that "it represented a clinical case of true contagious footroot. Unfortunately no organisms identifiable as Fusiformis nodosus were detected, but Spirochaeta penortha was abundant. While it has not been possible to prove that the disease is beyond doubt true contagious footrot, I have little doubt that the disease is that described by Beveridge, the clinical manifestations being so clear-cut together with the presence of Sp. penortha."

In view of this report and the writer's experience of the affected sheep at the Chapman Research Station, it is considered that the disease which occurred at the station was of the true contagious type.

History of the Outbreak.

Footrot suddenly appeared among the sheep at the station in July, 1930; when the sheep were examined over 90 per cent. had from one to four infected feet. The method of introduction is not known, but it is believed to have been brought to the station by a line of sheep purchased at that time.

During subsequent years the disease broke out in epidemic form during late winter and spring, and was quite severe in wet seasons.

The winter rainfall for the years 1935-38, particularly 1935 and 1938, was below average, and by the end of that period the outbreaks had become progressively less, and it was thought that the attention given, aided by the dry summer period, would finally eliminate it.

This was not so. The winter of 1939 was one of high rainfall and by the middle of September, within a comparatively short space of time, the disease had broken out freely.

By this time preliminary reports by the C.S.I.R. had indicated the present methods of control and eradication. The flock was treated accordingly and during the latter half of the following summer the system of eradication was being practised.

Treatment prior to 1939.

When the disease first made its appearance on the station the method of treatment was to clip the feet frequently, removing all loose horn, and pass the flock through a footbath containing a solution of bluestone and alum (two per cent. of each). The footbath was made of wood and was about 12 feet long and four inches deep, set in ground level in the drafting race of the sheep-yards. The addition of alum was intended to harden the hoof as by doing so, it was then thought that the wet conditions would be resisted more successfully and the possibility of infection lessened. This hardening of the hoof proved rather a detriment than an advantage as the horn became too hard to clip effectively, with the result that pockets were imprisoned by the rapidly growing horn. It is these pockets which we now know are such a factor in the carry-over of the disease from season to season. The use of alum was, therefore, discontinued and the strength of the bluestone raised to five per cent.

We then had no knowledge of the necessity for putting treated sheep into a clean paddock, and of using a much stronger solution in the footbath and treating the sheep thoroughly at much shorter intervals.

Although the outbreak each year was treated conscientiously and the treatment together with the favourable dry conditions of early summer resulted in the outbreaks being successfully controlled it was not realised that a few chronic cases, probably difficult to recognise, and also those whose feet were healed but whose horn completely enclosed pockets of infection, were sufficient and did carry the disease over the dry summer period, and so were the nucleus for a fresh outbreak the following season.

The 1939 *outbreak and subsequent treatment.*

An export lamb experiment was commenced at the station in December, 1938, by mating a flock composed of 300 Border-Leicester merino half-bred ewes and 275 merino ewes with Dorset Horn and Southdown rams. The merino ewes were selected

from the flock on the station and many of these had previously contracted the disease, but by November appeared quite free from it. The crossbred ewes were brought to the station from a footrot-free property in November before mating.

The winter of 1939 was very wet and in the light of past experience it was considered likely that footrot would again make its appearance. When crutched about the middle of April, the opportunity was taken to inspect the feet and no footrot condition was seen. At the end of May a few longtoes were clipped and again no footrot was apparent.

On 13th July the ewes and lambs were put through the footbath as a precautionary measure. The feet of those which were lame were examined and the lameness was found to be caused by doublegee wounds. The same treatment was given in August and no footrot was apparent. On the 12th September the incidence of lame sheep appeared higher than was usually due to doublegees, and upon inspection it was found that footrot had broken out. All sheep were immediately put through the footbath containing five per cent. bluestone solution.

Shortly after, and as soon as possible, the feet of all sheep were inspected and those affected were clipped to remove all free horn and swabbed with a mixture of powdered bluestone and Stockholm tar (1 : 6). All healthy feet were trimmed where necessary. The sheep were then put through the footbath, affected and doubtful sheep last. As all lambs had not been marketed it was not practicable to isolate the affected sheep.

By putting the sheep through the footbath every few days and at the same time keeping all affected feet well clipped back and painted with the bluestone-Stockholm tar mixture, the outbreak was controlled and yielded well to treatment. There was a number of stubborn cases among the merino ewes, of which quite a higher proportion than the crossbreds contracted the disease.

It was not known by us then that a much higher strength of bluestone solution, viz., 30 per cent., had a more rapid curative effect when used in a walk through footbath, and by the use of such a solution strength would have reduced the time taken to control the outbreak and effect a greater proportion of cures early in the treatment period.

Upon becoming acquainted with the information contained in the progress reports issued by the C.S.I.R. on the results of their investigation into the problem of footrot in sheep, it was decided to apply the recommended procedure for eradication in an endeavour to have the station completely free from the disease.

During the busy period of harvesting, grading, and carting, the flock was several times put through the footbath. At the end of February, 1940, all sheep were yarded. Every foot and claw was carefully examined and trimmed. All those which obviously still had the disease, together with suspect cases, i.e., those showing a bulge on the apparently healed foot and those which appeared to have unhealthy feet were taken off. The unaffected sheep were put through the footbath containing five per cent. bluestone and then placed in a paddock which had been unstocked for over three weeks. On no occasion was this footrot-free flock moved to any other paddock or yards unless these had been unstocked for at least three weeks.

The affected sheep had their feet well trimmed and were swabbed with the bluestone-Stockholm tar mixture. Those sheep with irregular shaped horn, i.e., unusual bulges in healed horn, had these bulges pared away in order to expose any

pocket of infection which may have been hidden by overgrown horn. The suspicious cases had their feet well trimmed and were also swabbed with the bluestone-Stockholm tar mixture. These affected and suspicious cases, numbering 76 in all, were placed in an isolation paddock and given regular treatment.

In mid April all sheep were inspected and no fresh cases were observed from the clean flock.

At the same time 46 were selected as completely cured from the isolation group and were put into a separate paddock for a month, at the end of which time, as they all appeared quite free of the disease, they were put back with the main flock and all put through the footbath as a precautionary measure.

On three occasions in July the feet of the main flock were carefully examined and, in all, 15 suspects were removed. Of these, only four proved to have a slight infection. These were the last suspects to be removed from the clean flock. A strict watch was kept for the remainder of the season and during the following seasons of 1941 and 1942, but no further cases have been found.

The isolation group of 48 comprised six crossbred ewes and 42 aged merino ewes. The great majority of these responded to treatment. As a precaution, however, they were not returned to the main flock, but were killed for rations. Several stubborn cases, which could not be cured by reasonable treatment, were slaughtered.

Now that such a long period has elapsed since any sheep from the main flock has shown evidence of having the disease, it is considered that footrot has been completely eradicated.

OBSERVATIONS.

During the period of treatment the writers were not aware that it was advisable to use a stronger solution than five per cent. in a walk-through bath. For that reason it is considered that an appreciably longer time was taken to effect cures. By using a 30 per cent. solution, as is now recommended, much time and work would undoubtedly have been saved.

The principal tool used in the cutting back of the horn was the double-bladed seccateur. This was found to be much more effective than the knife, except where paring was necessary, when it was used.

As has been stated so many times by those experienced in the treating of sheep with footrot, it was found essential to remove every part of the horn which was free and unattached in order to expose the whole of the area of infection.

When making the bluestone-Stockholm tar mixture, the bluestone was ground to flour and stirred into the tar.

When treating affected or suspected cases, care was taken to ensure that clean sheep were kept away from the place of treatment in order to prevent their walking on infected material.

A small number of cases of foot abscess were seen during the last outbreak, as distinct from the true footrot condition, and which no doubt originated principally from pus-forming organisms gaining access to the feet through wounds caused in the main by doublegees.

That the foot trouble was due practically wholly to the true footrot bacteria was indicated by the appearance of the affected feet as well as by the rapidity with which infection passed through the flock when conditions were favourable.

Great care was taken to ensure that clean sheep were not moved to any place where possibly infected sheep had been, until that place had been unstocked for at least three weeks. This period is longer than the fortnight recommended as ample under such conditions. This phase of the system of eradication is very important.

The work entailed in the system of eradication practised as outlined here proved to be far less, actually about one third, of the work required in the previous season to control the outbreak.

Farmers with sheep infected with footrot on their properties are strongly advised to eradicate the disease from their flocks. It can be done with a reasonable effort. The benefits in healthier sheep, better use of feed, and improved wool returns, are obvious.

Wild Flax.

(Linum marginale *A. Cunn. ex Planch.*)

C. A. Gardner, Government Botanist.

With the exception of the common cereals, rice and wheat, perhaps the oldest of the cultivated plants is the common flax (*Linum usitatissimum*). The origin of flax is shrouded in obscurity. It was cultivated by the Egyptians who made use of linen, the plant was figured in ancient Egyptian drawings, and the bandages used on the mummies were of linen. Herodotus mentions these uses. Linen was also woven by the Hebrews. It was also known to the Celts, and the ancient people of India; lastly flax was cultivated and woven by the lake-dwellers of Eastern Switzerland at a period when they used only stone implements, and by the prehistoric inhabitants of the peat-mosses of Lagozza, in Lombardy.

The earlier investigations of Planchon and De Candolle indicate that the common flax of cultivation (*Linum usitatissimum* L.) has not been discovered with absolute certainty in a wild state. It is certainly not native to India, but has been discovered in a "half wild" state between the Caucasus and the Caspian Sea. On the other hand, *Linum angustifolium* Huds., described as an annual or perennial, is known in a wild state over an area extending from the Canary Islands, through the Mediterranean region, including Morocco, Algeria, southern Europe, the Alps, and the Balkan mountains to the Caucasus, Lebanon and Palestine. It is very probable that this species represents the original form of the cultivated flax, and if so, would account for the distribution of flax cultivation in ancient times when there was no intercourse between Switzerland and Egypt. Discoveries made in Eastern Switzerland show that the flax of the lake-dwellers, was *Linum angustifolium*. We must recognise the fact that flax was indeed cultivated by the western Aryans before their arrival in Europe, and at the same time was in cultivation in Switzerland and northern Italy.

The native flax of Australia (*Linum marginale*) was formerly confused with *Linum angustifolium* referred to above, but differs in the union of the styles, otherwise the two are practically indistinguishable. It is curious that the Australian aborigines knew something of its uses, since Mueller refers to the native manufacture in Victoria, of nets, fishing lines and other "neat articles," while he further states that the seed has the same properties as linseed. Mueller also refers

to the bast as being of considerable strength, and its possible use as a commercial fibre. Unlike the northern *Linum angustifolium*, however, *Linum marginale* is always a perennial as far as is known, although, in this connection it should be remembered how, under cultivation, one form may pass into another, and it is probable that while the cool conditions of Switzerland and the Caucasus would support a perennial, this may not have been possible in Babylonia and Egypt. From the fact that Egyptians uprooted their flax, while the lake-dwellers cut their plants, we may assume that the plants were respectively annual and perennial.

It is indeed curious to find a plant so closely related to the northern perennial flax indigenous—in fact endemic—in Australia, with no geographical connections, for the species of flax do not occur anywhere in the tropics. It is even still more curious to find that this native flax has been discovered in Western Australia, far from any district where flax was cultivated, infected with a rust similar to that which attacks the cultivated flax. This fact was discovered by the Plant Pathologist, Mr. Cass Smith, when he found the rust present on specimens in the State Herbarium, collected near Wagin in 1920, when there was no cultivated flax in that district.

It was this discovery, together with the fact that the rust fungus had also been reported on native flax in South-Eastern Australia, that led to an investigation being undertaken recently by the Plant Pathologist of the Department of Agriculture and the author, to discover how general was this infestation.*

Together with previous records, it is now known that *Linum marginale* extends over a considerable area in Western Australia. Previous to our investigations, the plant was known only from the following localities:—

King George's Sound (*W. Baxter* circ. 1825).
Woodman's Point, near Fremantle (*Preiss*, December 1838).
Swan River Colony (*Drummond* 1839).
Princess Royal Harbour (*Preiss* Novem. 1840).
Doubtful Island Bay (*A. Oldfield* ? 1859).
Bremer Bay (*J. Wellstead*, 1901).
Wagin (*Gardner* October 1920).
Kellerberrin (*Gardner* 1926).

We discovered the plant in a few new localities, namely, 20 miles west of Brookton, three miles west of Wagin (the previous locality was "Lyndhurst," three miles north of Wagin), Bremer Bay, and Woodman's Point. A search made at Cape Riche failed to reveal the plant, but I have subsequently received specimens from *Mr. Neil O. Moir* at that locality. Other localities are: Boyup Brook, *H. G. Elliott*, and near Mount Lesueur, Hill River, *Lt.-Col. A. E. Watson*. Rust-infected plants were discovered at Wagin, Woodman's Point and Boyup Brook. All the plants seen near Brookton, and at Bremer Bay were entirely free from rust, while the two specimens received from Mr. Moir at Cape Riche, together with the two specimens from Mount Lesueur were entirely free from rust also.

In each of the localities where we found *Linum marginale*, careful notes were taken of the plants with which the plant was associated, as well as the soil. It was found that the plant inhabits particular types of country. In all cases this is open woodland with a ground flora in which the shrubs are scattered, and a large

*See article on flax rust by W. P. Cass Smith, this Journal, December, 1942.

amount of herbage, in which the native grasses are prominent. It is, in fact, a savannah woodland type in which the plant grows. Further, the flax plants occur in small scattered groups within this type of country. The following are typical examples:—

Inland localities:

Kellerberrin district.—Jam country, with scattered York gums, growing amongst the club grass (*Neurachne alopecuroides*), near granite rocks, together with *Dianella revoluta* and *Caesia parviflora*, *Grevillea biternata* var. *paniculata*, etc.

Brookton district (20 miles west of Brookton).—Granitic or lateritic-granitic soil on slopes, with Wandoo, Blackboy, *Hakea prostrata*, *Dryandra Fraseri*, *Bossiaea eriocarpa*, *Dianella*, *Caesia*, and *Neurachne*.

Wagin district (Badjaning water catchment area).—Granitic-lateritic soil, on hills or slopes, with wandoo, sheoak (*Casuarina Huegeliana*), *Hakea prostrata*, *Dianella revoluta*, *Neurachne alopecuroides*, *Bossiaea eriocarpa*, *Caesia parviflora*, etc.

Mount Lesueur, Hill River.—Lt.-Col. Watson informs me that the plants were growing in open woodland with an abundance of grass and other herbaceous ground covering. It is probably wandoo country, in sandy lateritic soil.

Coastal localities:

Bremer Bay.—In white or grey sand rich in humus, in open spaces in peppermint woodland, growing in association with *Hakea varia*, *Dianella revoluta*, *Neurachne alopecuroides*, *Caesia parviflora*, *Stylidium luteum*, and *Comesperma confertum*.

Woodman's Point, near Coogee.—In white sand with humus, in open tuart country in depressions, with *Dianella revoluta*, *Caesia parviflora*, *Poa Drummondiana*, *Stipa*, and *Comesperma confertum*.

The full lists have not been supplied, but there is an evident association of plants wherever *Linum marginale* occurs. For example, it is always associated with *Dianella* and *Caesia*, and certain native grasses; furthermore the coastal plant were associated with *Comesperma* and *Senecia lautus*, while the inland plants were always associated with *Neurachne alopecuroides*, and with the single exception of the Kellerberrin specimens, with *Stylidium luteum*, as well as the *Dianella* and *Caesia*. In fact, we may regard both *Dianella* and *Caesia* as indicator plants. No ecological evidence is forthcoming from the Boyup Brook district, except that the plants grew in wandoo country. Mr. Moir informs me that the Cape Riche plants grew in Yate country among grass, with a clay-gravelly soil, twenty or thirty plants being found within a few yards of each other.

Some knowledge of the environment in which the flax grows is very useful in locating the native flax, for the plant is not conspicuous, especially when the plants are small. As previously stated, they very closely resemble the cultivated flax, and it is only when the plants are in their second or third year of growth, and their perennial character is evident, that they can be separated on sight. In this latter stage the stem is branched at or close to the base, although some branching above may be observed, particularly in large plants. One plant collected at Wagin was thirty-nine inches high, and had its principal woody stem branched near the top, but frequently the main stem dies after the second year, and the secondary stems take its place. The root system is strong, consisting of a well

developed primary or tap-root, and strong laterals which penetrate to a considerable depth. The leaves are narrower than in most forms of the cultivated flax, and exhibit considerable diversity in shape and size, being sometimes short and narrow, on other plants they are long and lanceolate. The flowers are blue, this colour varying from a rich cobalt blue to a pale azure blue, and some forms are almost white. They are borne in loose branching inflorescences, and are about the same size as those of the cultivated flax. The styles, however, afford the principal distinction: those of the cultivated flax are all five entirely free to the base, while in *Linum marginale* they are united in a slender column to above the middle.

The following key serves for the purpose of identification of the three species of flax occurring in Western Australia, one being native, and two naturalised; of the naturalised species, one is the cultivated flax which also occurs in a semi-wild state in various localities as far north as Nangetty.

A. Flowers blue; stigmas decurrent along the inner surfaces of the styles.
   a. Styles free; capsule longer than the calyx; annual plant .. .. 1. *L. usitatissium.*
   b. Styles united above the middle; capsule not, or scarcely exceeding the calyx; perennial .. 2. *L. marginale.*

B. Flowers yellow; style free, the stigmas capitate .. 3. *L. gallicum.*

Linum marginale is found in Western Australia as far north as the Hill River, extending eastwards to Kellerberrin, Brookton and Wagin, and between Donnybrook and Dinninup, and is found in several coastal localities between Albany and Doubtful Island Bay, as well as at Woodman's Point, near Fremantle. It extends into South Australia, Victoria, Tasmania, New South Wales and southern Queensland, and shows considerable variation in its leaves and habit. It is probable that there are several varieties. It is hoped that with the help of the foregoing description, together with the accompanying illustration, people in the country will keep a watch for the plant. Any suspected specimens should be forwarded for determination.

Linum usitatissimum, the cultivated flax is being grown on a large scale, and is also becoming naturalised, as for example, along railways and roads in the South-West. It is also naturalised in the Guildford district, and the author collected specimens at Nangetty, near Mingenew, in 1939.

Linum gallicum is a weak annual that it naturalised in damp spots between Harvey, Bunbury, and Donnybrook. It has small yellow flowers.

The native flax is of no known commercial value, but is interesting at the present time, and at the same time important, because of its rust fungus which attacks the commercial strains of flax. At the same time, being a perennial, it possesses a fibre that might well be worth exploitation, although it would be necessary to cultivate the plant for the purpose.

Although flax is commonly cultivated for its fibre, and for linseed, the oil of which is valuable as a drying oil, the residuum as a stock food, and although it has reputed medicinal values, it is perhaps not generally known that a valuable wax is obtained as a by-product during the combing and drawing processes, from the dust or "pouce" which accumulates during the preparation of the fibre. This dust yields 10 per cent. of a hard wax which much resembles beeswax but is harder and more brittle, and with a higher melting point, and, although not as hard as carnauba wax, is more durable.

Linum marginale A. Cunn. ex Planch.

Wagin, W. Austr. 8 Oct., 1942.

A, Habit. A1, Leaf (enlarged). B, Inflorescence (two-thirds natural size). C, Flower (enlarged). D, Calyx (enlarged). E, Sepal (enlarged). F, Portion of flower with petals and two stamens removed. G, Gymoecium.

Notes on Plant Diseases.

W. P. CASS SMITH, Plant Pathologist.

THE CONTROL OF LOOSE OR FLYING SMUT OF WHEAT.

(*Ustilago tritici*).

Loose smut of wheat occurs in greater or lesser amounts wherever wheat is grown. The disease is very obvious, for both grain and chaff of an affected head are converted into a loose mass of dusty black spores at about the time healthy wheat is flowering. The spore masses are at first covered by a delicate membrane, but this soon bursts, and the spores are blown away, so that by harvest only bare stalks remain. (See Plate 1.)

LIFE CYCLE.

Unlike bunt or covered smut of wheat, infection occurs at flowering time. The loose smut spores from infected plants are blown about by wind and some eventually lodge in the open flowers of other healthy plants, and on the stigmas or sensitive portions of the embryo grains. Here the spores germinate, sending out infection threads which penetrate the young developing grains. These continue to develop apparently quite normally, and at harvest time show no visible differences from healthy grains.

However, the fungus lies dormant within infected seed and commences to grow again when the latter is planted the following season. As the seed germinates, the fungus enters the young shoot, growing with it until it heads. At heading time the fungus makes a vigorous development, converting the grain and chaff into a black spore mass as already noted.

CONTROL OF LOOSE SMUT.

As the fungus is carried within infected seed, dusting with copper carbonate as for the control of bunt is ineffective. For direct disinfection of the seed, Jensen's hot water treatment, or modifications of it, are used. Basically these treatments consist of steeping the grain in water at a certain temperature and for a sufficient duration, to kill the fungus without injuring the seed. As the temperature required to kill the fungus is little below that at which seed injury occurs, delicate control of temperature is necessary, otherwise the treatment may be ineffective or too injurious.

Owing to attendant difficulties, hot water treatments have not been recommended for application by farmers. To control loose smut in wheat the latter have been advised to sow pedigree seed obtained from a research station, or to obtain seed wheat from other healthy crops in their districts.

At the research stations every effort is made to reduce the disease to negligible amounts by hand rogueing both test rows and accumulation plots, and by isolating them from other crops of wheat.

This system has for years given satisfactory results, though at times introduced seed has caused considerable trouble and extra work.

However, during the last year or two, loose smut appeared to be increasing at one research station on the varieties Merredin and Koorda. It was therefore decided to attempt control by applying a hot water treatment, to some 24 bags of seed of these varieties, and this was carried out on the 20th, 21st, and 22nd April, 1942.

Plate 1.
Wheat affected with loose smut.

DETAILS OF HOT WATER TREATMENT.

As a result of preliminary laboratory experiments and having regard to the available equipment at the research station, and the amount of seed to be disinfected, the following treatment was adopted:—

(a) Pre-steep in water to raise the temperature of the grain to 120° F. as soon as possible.
(b) Steep in water at 120° F. for 95 minutes.
(c) Cold water immersion followed by drying.

In the pre-steep the grain was brought to the desired temperature by immersing it in water held in 44-gallon drums. Six bushels were treated at the one time, the grain being loosely held in cornsacks, each containing one bushel. The tem-

perature was regulated by the addition of hot water, ample supplies of which were at hand, and the bags were kept well agitated.

For the steep proper, a square 200-gallon tank with top removed, was sunk into the ground, the sides and bottom being well insulated with straw.

After attaining the desired temperature, the pre-steeped wheat was quickly transferred to the 200-gallon tank, in which water at 120° F. was already present and held for 95 minutes.

The bags were suspended from two rods placed across the top of the tank and by raising and lowering them at frequent intervals, good water circulation was secured.

The Assistant Plant Pathologist, Mr. L. Harvey, who supervised the application of the treatment, reported that it took approximately 10 minutes to bring each lot of pre-steeped wheat to the correct temperature. Also in the main steep good control of temperature was obtained with this limited equipment, the range being from 119°-121°F. Unfortunately, the supply of cold water for the final immersion was inadequate, and it was anticipated that this might adversely affect the subsequent germination of the grain.

RESULTS.

In order to study the effect of treatment, samples of both treated and untreated seed of each variety were planted on 9th June, 1942, under test row conditions. All seed had been dusted with an organic mercury dust some six weeks prior to sowing, at the rate of 2 ozs. per bushel. The dust was applied to protect any seeds mechanically injured by the hot water treatment from attacks by mould fungi in the soil during germination.

Germination counts were taken in the test rows, and at flowering time several inspections were made to remove and count loose smut affected plants.

	Merredin.		Koorda.	
	Treated with Hot Water.	Untreated.	Treated with Hot Water.	Untreated.
	%	%	%	%
Germination	70·5	78·6	61·4	80·3
Loose smut-affected plants	...	2·1	...	1·0

From the table above it will be seen that treatment had a depressing effect on the germination of the grain, especially of the Koorda variety. However, owing to the shortage of cold water for the final immersion, the retention of heat by the treated seed was unduly prolonged, and no doubt this was partly responsible for the subsequent depression of germination.

Also during the growing period it was noticeable that weaker seedlings developed from treated than from untreated seed. However, during growth the weaker plants gradually became more robust until at flowering time the difference in vigour between each lot was much less marked.

It will also be noticed from the table that the hot water treatment was very effective in controlling the disease, for *not a single plant affected with loose smut developed from the treated seed of either variety.*

Furthermore, no plants affected with loose smut were discovered during inspections of the bulk plots where the balance of the treated seed was sown.

As this is the first occasion on which a hot water treatment for controlling the disease has been attempted here, the results are very encouraging, for by this means, it will now be possible to reduce the amount of loose smut in pedigree seed to even lower levels than hitherto.

GERMINATION OF PEAS IMPROVED BY DUSTING SEED WITH COPPER CARBONATE.

During recent months many complaints have been received from growers in the metropolitan and adjacent districts concerning poor germination in planting of peas. This has occurred in most cases in old soil, fairly rich in organic matter, rather than in new soil, and investigation has shown the condition to be largely due to pre-emergence damping-off.

Pre-emergence damping-off is caused by parasitic mould fungi which attack the seeds and kill the young shoots before they emerge above ground. The organisms responsible may be introduced to the soil on the seed coat, particularly when defective samples containing cracked, shrivelled or discoloured seeds are sown, or they may already be present, especially in old soil.

To ascertain if improved germination would result from dusting the seed with fungicidal dusts, the following experiment was carried out in the Forrestfield district on land where pre-emergence damping-off had seriously reduced the stand of peas a few weeks earlier.

Commercial seed samples of four popular varieties, Greenfeast, W. F. Massey, William Hurst, and Yorkshire Hero, were purchased and when tested in the laboratory by the Government Botanist, the germination of all varieties was satisfactory, exceeding 90 per cent.

The seed of each variety was divided into three lots and treated as follows:—

Lot I. Dusted with an organic mercury dust at the rate of 1½ ozs. per bushel.

Lot II. Dusted with copper carbonate (identical with that used for pickling wheat) at the rate of 2 ozs. per bushel.

Lot III. Control, no treatment.

Using a randomised block design the experiment was planted with 50 seeds per treatment row and each treatment was replicated eight times.

RESULTS.*

Varieties.	Percentage Germination.		
	Organic Mercury Dust.	Copper Carbonate Dust.	No treatment Control.
Greenfeast	17	48	8
W. F. Massey	36	60	13
William Hurst	14	35	2
Yorkshire Hero	35	67	9
Mean Germination, all varieties (per cent.)	25	53	8

*Statistical analysis of the results was undertaken by the Deputy Conservator of Forests, to whom the author's thanks are due.

CONCLUSIONS.

From the table of results it will be seen that the germination of all varieties was very low when non-dusted seed was planted in soil subject to pre-emergence damping-off. The germination of each variety was considerably improved when the seed was protected prior to planting, with a film of either organic mercury or copper carbonate dust, but the latter substance was superior to the former for this purpose.

Taking the mean percentage germination of all varieties, seed protected with copper carbonate dust gave approximately seven times the germination of non-dusted seed, whereas seed protected with an organic mercury compound gave only three times the germination of non-dusted seed.

RECOMMENDATIONS.

When planting peas in soil where pre-emergence damping-off has previously caused poor stands, it is a wise precaution to coat the seed with a protective layer of copper carbonate dust. The dust should be applied at the rate of two ounces per bushel, and seed and fungicide should be shaken together in a closed container for two to three minutes.

When treating small lots of seed this rate of application may be obtained approximately by adding one level saltspoon of copper carbonate to a sixpenny packet containing four ounces of seed, or one level teaspoon to each pound of seed.

It should be noted, however, that inoculated seed should not be treated with a fungicidal dust as the fungicide will kill the nodule-forming bacteria.

FLAX RUST.

"WILD FLAX" HARBOURS THE DISEASE.

Attention has previously been drawn through the medium of this Journal to the local occurrence of flax rust (*Melampsora lini* (Pers.) Lév).*

Since then it has become abundantly clear that the successful cultivation of flax in Australia, both for fibre and oil, will depend very largely on the control of the diseases of this plant. Of these, flax rust and wilt are probably the most serious, and to combat them the Commonwealth Flax Production Committee is arranging for the breeding of resistant varieties.

Fortunately flax wilt has not yet made its appearance in Western Australia, and every effort is being made to prevent its introduction. Flax rust, on the other hand, has developed annually in this State since commercial cultivation commenced in 1941, and both last season and this it has proved a serious limiting factor to the cultivation of linseed, and to a lesser extent of fibre crops.

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*Cass Smith, W. P.—Flax Rust, Jour. Dept. Agric., West. Aus., 2nd ser. 19. 56-63, 1942.

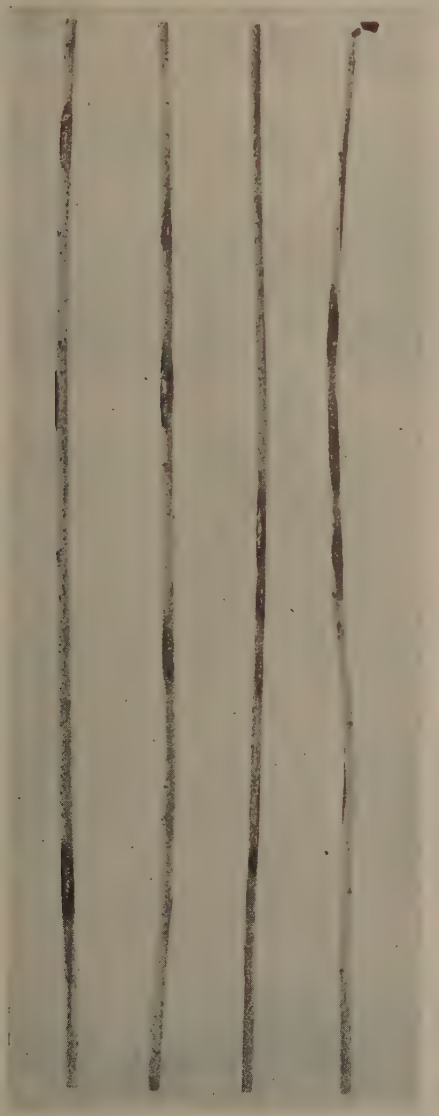

Plate 2.

Portions of flax stems affected with the teleutospore stage of flax rust. The blackened areas (teleutosori) have a hard, crust-like, slightly raised surface and they are very noticeable on the stems in marked contrast to the golden colour of the healthy stem tissue. Under favourable conditions for its development, flax rust considerably lowers the yield of seed crops, but even light infections may cause serious damage to fibre varieties by discolouring and weakening the fibres and thus reducing fibre quality.

(Photo by Government Photographer.)

Experience both here and elsewhere in the world has shown that once the disease becomes widespread the breeding of resistant varieties is the only satisfactory method of control, and this has now become a major aim throughout the Commonwealth.

This work is complicated by the fact that the parasite is known to comprise at least 24 races which vary considerably in pathogenicity on different varieties. Thus a variety resistant or immune to one race may be highly susceptible to another race of the fungus.

Dr. W. L. Waterhouse and co-workers at the Sydney University, to whom the difficult task of breeding rust-resistant varieties has been entrusted, have therefore emphasised that the success of such a breeding programme will depend on an accurate knowledge of the races of flax rust present in Australia.

Accordingly collections of rusted flax and linseed plants, and observations on varietal reactions to the disease, are being made in all States.

Already from rusted material collected locally at least two races of the parasite have been isolated by Dr. Waterhouse.

The linseed variety Punjab is susceptible to one of these races, and resistant to the other, while the reverse is true of the fibre variety Concurrent.

Recently evidence has been obtained that the "wild flax" (*Linum marginale*) may also play an important part as a host of this disease. As mentioned elsewhere in this Journal, "wild flax" affected with flax rust was recently collected in the Wagin, Boyup Brook and Woodman's Point areas, and it is quite likely that from these specimens further races will be isolated.

On both cultivated and wild flax the disease becomes very evident by the appearance of bright orange coloured pustules on stems, foliage or floral parts. Later in the season the colour of the pustules gradually changes to black (see plate 2).

Persons living in country districts can therefore greatly assist this work by studying the article on "Wild Flax" by the Government Botanist (Mr. C. A. Gardner) which appears in this Journal, and by forwarding any diseased specimens they find to the Plant Pathologist. In addition, mature seed of both healthy and diseased plants is required. By so doing, they will make a valuable contribution to the war effort, for flax and linseed are urgently needed both for civilian and service requirements.

Experiments with Micro-Elements for the Growth of Crops in Western Australia.

VI. FURTHER RESULTS FROM THE USE OF COPPER-CONTAINING FERTILISERS IN THE WHEATBELT.

L. J. H. TEAKLE, Plant Nutrition Officer.

1.—SUMMARY.

1. A number of experiments with copper-containing fertilisers are described. Observations made by farmers using bluestone-superphosphate mixtures in 1941 are summarised.

2. Benefit from the use of copper-containing fertilisers was obtained in some experiments, but not in others.

3. About one-third of the farmers known to have used bluestone as a fertiliser in 1941 reported beneficial results.

4. Types of country most likely to be acutely deficient in copper for cereal crops include:—

(a) Sandy and gravelly wodjil types.

(b) Similar soils carrying tamma and scrub in some districts.

(c) The general soil types of the Dandaragan and Gingin districts.

(d) Calcareous sand hill soils in coastal districts. Zinc as well as copper was found to be necessary in an experiment on this type of country near Dongarra.

5. The use of fertilisers containing copper will correct the deficiency.

6. It is recommended that the application of copper be equivalent to 5 lbs. of bluestone per acre for the correction of copper deficiency under wheatbelt conditions.

2.—INTRODUCTION.

The value of copper-containing fertilisers for cereal crops on certain soil types in the wheatbelt has been discussed in a number of previous papers in this Journal (Teakle, Turton & Throssell, 1940; Teakle, Thomas & Turton, 1941; Teakle, Morgan & Turton, 1941; Burvill & Teakle, 1942; Wild & Teakle, 1941 and 1942). In general, it has been found that the soils on which cereals are responsive to copper fertilisers are light sandy and gravelly types. Some are described by farmers as wodjil soils and all are admittedly of low inherent fertility. Taken on their own these soils may not be worth the expense of improvement for cereal production, but they usually occur intermixed with the better soil types which form the basis of wheatbelt agriculture. Under wheatbelt methods it is therefore impossible to eliminate them from the cultivated area, and machinery has to be drawn over the crops on such unsatisfactory soil types for very little produce. Any treatment which can increase production on these soil types, even by a small amount per acre, will be an advantage. It is probable too, that not only will there be some increased production of cereals on these copper deficient types, but also the quality of the pasture in succeeding years will be improved.

As described in the paper by Wild and Teakle, 1942, wheat on copper deficient land exhibits a variety of symptoms depending on the severity of the deficiency and, probably, other conditions. A common feature is the failure to form grain in the heads after a reasonably normal growing period. In most acute cases the seedlings grow normally for only a few weeks. The first sign of trouble is a yellow tipping of the leaves and a wilted appearance of the plant. Root development is restricted. Later, stem elongation does not proceed normally and the plants collapse and die before the spring growth would be expected to commence. Moderate copper deficiency may be indicated by the excessive bending over of the wheat stalks. There may not be much, if any, loss in grain production. This condition is illustrated by photographs taken on Messrs. McKay Bros.' farm, Wyola, by Mr. F. V. Knapp, Agricultural Adviser for the district. See Figure 1. In this case not only did the stalks bend over, but the heads tended to break off after ripening where affected by moderate copper deficiency.

To obtain further information regarding the occurrence and cure of copper deficiency on wheat soils a number of experiments were carried out in 1941 and enquiries made from farmers who were known to have tried copper fertilisers on their properties.

3.—THE EXPERIMENTS.

A. *Sandy and Gravelly Soil Types.* (Experiments arranged by Mr. F. V. Knapp and Mr. W. M. Nunn.)

The experiments were arranged on light soil types generally where mineral deficiencies were suspected. The object was to obtain quantitative data regarding the effect of bluestone applied mixed with the superphosphate and, in some instances, a comparison with other types of copper-containing fertilisers, including oxidised copper ore and roaster residues. A summary of the results obtained are given in Table 1.

Oxidised copper ore failed to prove effective at the only site where it was used on soil giving a response to bluestone in 1941 (Mungedar). In the wheatbelt generally, however, copper ore mixed with superphosphate has proved equally as effective as bluestone, and if procurable at a reasonable price may be substituted as a convenient source of copper for fertiliser purposes.

A number of interesting points arise from the results given in Table 1.

(i) On Mr. Williams' property, Minnivale, a substantial improvement in the growth of wheat occurred where copper was used in 1940 on similar soil in an adjacent paddock. (Teakle, Thomas & Turton, 1941, page 79.) With superphosphate only the yield was 1.5 bushels per acre against 8.8 bushels where copperised super was used. Wheat grown on this country in the past had always been badly affected by white-heads and it was expected that the degree of copper deficiency would make this a suitable site for testing the merits of various sources of copper for wheat. However, the good seasonal conditions of 1941 resulted in a good crop, irrespective of treatment, so the purpose of the experiment was not achieved. Furthermore, the plots were damaged by a severe wash from higher land above the plots and harvester data, accurate enough for the comparison of very similar treatments, could not have been expected. The small differences noted are not significant.

(ii) Mr. Flavel's plots were on a type of wodjil country intermixed with salmon gum and morrel types. Without copper the crop consisted mainly of white-heads -the grain amounted to only 13 per cent. of the straw weight (total produce minus grain). With copper the heads filled normally and the grain amounted to 63 per cent. of the weight of straw. It was of interest that on the adjacent paddock which had been under wheat in 1940, the timber soils carried barley grass while the copper deficient wodjil types produced a heavy growth of capeweed.

(iii) On Messrs. Pope Bros.' property, Caron, the experimental strips were 28 chains long and covered three main types of soils. Yield data were obtained for each of these types of soil by means of hand cuts prior to harvesting the plots with a machine.

The central part where the soil contained considerable clay accumulation showed no response to copper. At the west end the soil was sandy and gravelly, but showed a hard pan at a shallow depth. Here the response was slight. The main response was on the east end of the plots where the soil was of a loose gravelly type and had carried low wodjil. On the superphosphate plots the heads failed to fill satisfactorily with the result that the grain amounted to only 14 per cent. of the straw weight. On the copper-treated plots the grain: straw ratio ranged from 56-67 per cent.

(iv) On Messrs. Herley Bros.' property, Gunyidi, the plots were laid down on typical heath country of the Watheroo district, which has proved suitable for

TABLE 1.

YIELD OF CEREAL GRAIN RESULTING FROM THE USE OF FERTILISERS CONTAINING COPPER ON SOIL TYPES OF THE WHEAT-BELT.

Farmer.	District.	Soil Conditions.	Crop.	Control Superphosphate.	Fertiliser Treatment. Superphosphate plus— Bluestone 5 lbs. per acre.	Bluestone 10 lbs. per acre.	Copper Ore equivalent to 10 lbs. Bluestone per acre.	Roaster Residues.	Difference for Significance at P = ·05.
				bus. per acre.	bus. per acre.	bus. per acre.	bus. per acre.	bus. per acre.	bus. per acre.
1. S. Williams ...	Minnivale (Hindmarsh)	Sandplain—sandy soil ...	wheat (Rajah)	17·8	18·0	18·3	19·2	18·0	...
2. R. Flavel ...	Ballidu ...	Wodjil country. Sandy surface on gravelly sandy loam with loose gravel at nine inches	wheat (Gluyas Early)	2·2	12·4	...	...	...	...
3. Pope Bros. ...	Caron	Wodjil and scrub country—							
		(*a*) gravelly sand with hardpan at 13 inches	wheat (Merredin)	7·1	8·9	...	...	...	...
		(*b*) gravelly sandy loam to sandy clay loam. Hardpan at 14 inches	do.	9·3	9·4	...	...	...	...
		(*c*) loose gravelly sand, very gravelly with depth	do.	1·2	8·5	...	...	...	...
		(*d*) harvester yields—whole plots	do.	8·0	9·0	...	...	10·4	...
4. Herley Bros. ...	Gunyidi ...	Sandplain—sandy soil with quartzite rubble in subsoil	barley (6 row)	16·8	16·8	13·0	16·1	18·1	2·2
5. Mungedar Pastoral Co.	Dandaragan ...	Red gum country—reddish sandy soil	oats (Guyra)	17·7	18·8	20·6	18·5	23·4	2·5
6. Yaodabbie - Barrett - Lennard, Wedge & Kyle	do. ...	Red gum country—reddish sandy soil	oats (Mulga)	12·8	...	19·8	...	21·0	5·6

barley production. The soils are very light and, at the site of the plots, appeared to be derived from a quartzite formation. A foot of grey to whitish sand rested on a subsoil of sand and quartz rubble. Laterite gravel was not observed.

The experiment involved a number of treatments including bluestone, copper ore, and roaster residues. Yield data indicate that the application of these substances in addition to the superphosphate had no significant beneficial effect. There was a tendency for the roaster residue plots to be slightly superior, but differences were too small to be more than suggestive. Perhaps some deficiency may develop on these soil types as the cropping programme is continued.

(v) Experiments in the Dandaragan district were conducted on Mungedar and Yaodabbie, using oats as an indicator crop. In each case the reddish sandy soils typical of marri and banksia country of the district were used and the most obvious response was to copper. There appears to have been some additional response where roaster residues were used. Again, the main effect appeared to be on the production of grain. At Mungedar the use of 10 lbs. of bluestone per acre with the superphosphate raised the grain: straw ratio from 34 per cent. to 40 per cent. At Yaodabbie the increase was from 26 per cent. to 40 per cent.

At Yaodabbie a collateral experiment was carried out in 1941 to test the effect of phosphate, copper, manganese, and zinc in all possible combinations on the growth of oats. When in the seedling stage there was a consistent response to superphosphate, but not to the other elements. At harvest, there was no apparent response to phosphate, manganese, or zinc, but the plots receiving copper were consistently superior to those on plots not receiving copper.

Results are summarised in Table 2.

TABLE 2.

YIELDS OF OAT GRAIN FROM PLOTS OF A FACTORIAL EXPERIMENT AT YAODABBIE, DESIGNED TO DETERMINE THE EFFECT OF ALL POSSIBLE COMBINATIONS OF SUPERPHOSPHATE, ZINC SULPHATE, MANGANESE SULPHATE, AND BLUESTONE, ON REDDISH SANDY SOILS OF MARRI AND BANKSIA COUNTRY.

Rates of Application—

Superphosphate	2	cwt. per acre
Zinc sulphate	5	lbs. per acre
Manganese sulphate ...	15	„
Bluestone	10	„

Fertiliser.	Yield of Grain (bushels per acre).	
	With.	Without.
Superphosphate	15·9	16·9
Zinc Sulphate	16·9	15·9
Manganese Sulphate	17·2	15·5
Bluestone	19·2	14·0

Difference for Significance at P = ·05, ± 2·5 bushels per acre.

Observations were also made on the plots sown on Yaodabbie in 1940. These were again sown with oats in 1941, this time without any fertiliser.

The yields of oat grain are given in Table 3.

TABLE 3.

YAODABBIE—YIELD OF OATS SOWN WITHOUT FERTILISER IN 1941 ON PLOTS TREATED WITH VARIOUS FERTILISERS IN 1940.

Fertiliser applied in 1940.	Yield of Oat Grain in 1941.	Yield of Total Produce.	Grain : Straw Ratio.
	bush. per acre.	tons per acre.	
No fertiliser	5·5	·51	24
Super only	12·0	·87	32
Super plus Bluestone	18·2	1·00	48
Bluestone only	22·3	1·04	62
Super plus Roaster Residues	19·6	·94	60

Again the effect of copper-containing fertilisers on the yield and proportion of grain produced is indicated. It is also to be noticed that the second crop has responded very markedly to the superphosphate residue on the plots not receiving bluestone. It has been mentioned above that the superphosphate had a substantial effect in promoting early growth of oats in the factorial experiment. The better yields of the oats after superphosphate applied in 1940, as compared with unfertilised plots, may be due to the beneficial effect of phosphate on the early growth being reflected at harvest time. Observations in 1942 indicate that the volunteer pasture cover was also very much improved where superphosphate had been applied in 1940.

The results show, however, that bluestone alone has effected greatest improvement in yield.

B. *Experiments on Calcareous Coastal Sand Hills at Dongarra.* (Arranged by Mr. N. Davenport.)

In 1940 a trial on the wattle sand hill soils on Mr. M. Ferries' property, Dongarra, indicated response of wheat to roaster residues but not to bluestone (oxidised copper ore dissolved in sulphuric acid). This pointed to a deficiency of zinc on this soil type. Consequently, in 1941, an experiment was arranged to test the effects of copper and zinc singly and in combination.

The harvester results from the experiment are given in Table 4.

The differences due to roaster residues, which contain both copper and zinc, and to a combination of copper and zinc are significant and indicate that, in addition to superphosphate, these soils require both copper and zinc in combination for maximum yields of wheat. The most effective rates required for these soils have not been determined. In view of the high lime content of these soils it is probable that heavier dressings than those used would be more beneficial. It is of interest that it is reported that copper and zinc in combination have proved beneficial on similar country in the south-east of South Australia.

4.—REPORTS OF FARMERS REGARDING THE VALUE OF BLUESTONE.

A questionnaire was sent out to 74 farmers known to have used bluestone and superphosphate mixture for cereal crops during 1941. Forty-three replies were received and of these 21 reported benefit from the use of the copper fertiliser. Two of the farmers reporting no benefit in 1941 had used bluestone in 1940 with

positive results on similar soils. It is thought that the very much improved seasonal conditions in 1941 had obscured the copper deficiency observed in the previous year.

TABLE 4.

YIELD OF WHEAT (RANEE) ON MR. M. FERRIES' PROPERTY, DONGARRA, WITH VARIOUS FERTILISER TREATMENTS.

Soil: Grey Calcareous Sand.
Vegetation: Wattle and Scrub.

Fertiliser.	Yield of Wheat.
	bushels per acre.
Control—Super only—1 cwt. per acre	12·2
Super—1 cwt. per acre	12·2
Bluestone—10 lbs. per acre	
Super—1 cwt. per acre	11·6
Zinc Sulphate—5 lbs. per acre	
Superphosphate—1 cwt. per acre	13·7
Roaster Residues equivalent to Bluestone—5 lbs. per acre	
Superphosphate—1 cwt. per acre	13·0
Roaster Residues equivalent to Bluestone—10 lbs. per acre	
Superphosphate—1 cwt. per acre	15·5
Roaster Residues equivalent to Bluestone—20 lbs. per acre	
Superphosphate—1 cwt. per acre	14·6
Bluestone—10 lbs. per acre	
Zinc Sulphate—5 lbs. per acre	

Difference for Significance at P = .05, ± 1·2 bushels per acre.

As it is probable that those not replying to the questionnaire observed no response, it should be concluded that less than one-third of the farmers known to have tested the superphosphate-bluestone mixture in 1941 were satisfied that benefit had been derived. There is good agreement that the sandy and gravelly soils, particularly the so-called wodjil types, are most likely to respond to copper. In a few instances it is claimed that cereal crops on the better class soils have been improved. These cases warrant further investigation.

A summary of the replies is given in Table 5.

Positive responses have been observed in other years from Kununoppin, Minnivale, Wagin, Dumbleyung, Muchea, and Gingin. In the wetter districts many positive responses to the use of bluestone have been reported from the districts of Albany, Denmark, Walpole, Northcliffe, Busselton, and Margaret River.

5.—DISCUSSION.

The question of copper deficiency in Western Australia has received much attention over the past five years and workers in plant and animal nutrition have shown that the supply of soil copper is subnormal in many parts of the State. The accompanying map (Figure 2) shows centres where the use of copper fertilisers is known to have given beneficial results.

TABLE 5.

SUMMARIES OF REPORTS FROM FARMERS WHO HAVE USED BLUESTONE-SUPERPHOSPHATE MIXTURES FOR CEREAL CROPS DURING 1941.

74 Enquiries were sent out.

Replies Received—43. Positive Responses—21.

	Name.	District.	Soil Types.	Response.
1.	F. F. A. Jaeschke ...	Bunjil ...	... ...	*Nil.*
2.	F. Summers	Latham ...	Light land (mixed scrub) ...	*Nil.*
3.	A. J. Hammat ...	Buntine ...	(*a*) Sandy York gum country	Positive.
			(*b*) Tussocky light sandplain	Positive.
			(*c*) Sandplain (mixture of types)	*Nil.*
4.	E. R. C. Harris ...	Wubin ...	(*a*) Mixed types	*Nil.*
			(*b*) Gravelly sandplain ...	3 bushels per acre.
5.	C. W. Honner ...	Dalwallinu ...	... ...	5–7 bags per acre.
6.	R. Flavel	Ballidu ...	(*a*) Tree wodjil	4 bags per acre.
			(*b*) Forest	*Nil.*
7.	W. Bartlett	Watheroo ...	Poor sandplain	*Nil.*
8.	A. E. Holdsworth ...	Benjaberring	Gimlet and blue mallee ...	Wheat no response (controlled Septoria).
9.	E. Lang	Coomberdale	Sandplain west of Coomberdale	*Nil.*
10.	Mungedar Pastoral Co.	Dandaragan	Red sandy soil	Positive.
11.	C. J. Roberts ...	do.	Grey-brown sandy soil ...	Positive.
12.	A. L. Longman ...	West Koojan	Sandy loam	Positive.
13.	J. H. Locke ...	Muchea ...	Black loam and sands ...	Positive.
14.	T. H. Swannell ...	Herne Hill ...	Darling Range country ...	*Nil.*
15.	R. H. Seymour * ...	Miling ...	Gravelly wodjil country ...	*Nil.*
16.	V. W. Stehn ...	Kulja ...	(*a*) Wodjil and broom ...	*Nil.*
			(*b*) Mallee and wodjil ...	Reduction.
17.	J. Freeman-Smith ...	Burakin ...	(*a*) Yellow sandy land, no clay subsoil	Positive.
			(*b*) Similar, but clay subsoil	*Nil.*
18.	E. J. Lego	Cadoux ...	Various	Positive on some wodjil with oats.
19.	H. C. Hobden ...	Wyalkatchem	(*a*) Poor sandplain ...	Positive.
			(*b*) Heavy land	*Nil.*
20.	E. A. Metcalfe ...	do.	... ...	*Nil.*
21.	Rowlands Estate ...	do.	... ...	*Nil.*
22.	T. H. Wilson ...	do.	(*a*) Mallee and wandoo (*b*) Wodjil ... ... (*c*) Broombush ... (*d*) Second grade plain	Generally improved growth. Wheat 4in. taller. Heads better filled.
23.	L. Naughton ...	Yorkrakine...	... ...	*Nil.*
24.	S. Williams † ...	Hindmarsh...	Sandplain	*Nil.*
25.	R. E. Jones	Dowerin ...	Wodjil	Positive.
26.	J. Appleyard † ...	Kununoppin	do.	*Nil.*
27.	M. Appleyard ...	do.	... ...	*Nil.*
28.	G. W. Inman ...	Koorda ...	... ...	Positive.
29.	C. H. Smith ...	do. ...	... ...	*Nil.*
30.	H. J. Shadbolt ...	Mukinbudin	(*a*) Wodjil	10 bushels per acre.
			(*b*) Broom, tea-tree, and mallee	*Nil.*
31.	T. W. Smith ...	Cunderdin ...	Wodjil	Positive.
32.	McKay Bros. ...	Wyola ...	(*a*) Scrub (scrub wodjil) ...	*Nil.*
			(*b*) Tree wodjil	5 bags per acre.
33.	B. Waud	Merredin ...	... ...	*Nil.*

TABLE 5—*continued.*

Name.	District.	Soil Types.	Response.
34. C. Jose	Corrigin ...	(*a*) Scrub plain— (i) Yellow sand (ii) Ironstone	Positive.
		(*b*) Timber	*Nil.*
35. A. Tuia	do. ...	Wandoo and scrub ...	*Nil.*
36. Bebbington Bros. ...	Bullaring ...	Gravelly, sandy soil ...	Positive.
37. R. Dunwell	Yealering ...	Sandplain (gravelly soil carrying low scrub and blue bush)	Positive.
38. Alf Holmes	Duranillin ...	Red gum (sandy gravel); Sheoak (sand, clayey ground)	*Nil.*
39. C. H. Lucas ...	Lake Grace...	Sandy York gum country	Positive.
40. J. T. Magner ...	Ongerup ...	Moort	*Nil.*
41. T. Hick	West Dale ...	Good jam country ...	*Nil.*
42. R. W. Williamson ...	do. ...	Wandoo, jam, York gum, sub. clover	*Nil.*
43. H. Garmody ...	Jandakot ...	Banksia and paper bark (sand)	*Nil.*

†Responses obtained on this soil type, 1940. Failure to obtain response in 1941 deemed to be due to the favourable spring conditions.

* *Harvester Yields* on Mr. R. H. Seymour's property, Miling :—Super only, 12·9 bushels ; Super + Bluestone, 11·7 bushels ; Super + Roaster Residues, 12·1 bushels.

While the widespread distribution of copper deficient soil types is recognised, the proportion of the crop and pasture land of the State affected cannot be gauged. It can be stated, however, that, in the wheatbelt, the forest and other heavy soils, and much of the sandplain country are generally not deficient in copper as far as crop and pasture growth are concerned. Copper deficiency is known to be more or less acute only on certain types of sandy and gravelly soils such as wodjil country, tamma country in some districts, on some types of sandplain, and on the soils typical of the Dandaragan and Gingin districts. These conditions of acute deficiency are easy to detect and the disorder is easy to control by the application of bluestone at the rate of about 5 lbs. per acre.

More difficult to detect are the soils subnormal, but not acutely deficient, in copper. Bennetts, 1942, suggests that stock on many light and intermediate soils such as are associated with wandoo country, exhibit subnormal copper status, although deficiency symptoms in the crops are absent. Beck, 1942, has given valuable corroborative evidence from the analyses of a wide range of pastures.

In view of these observations an extensive series of subterranean clover samples has been collected from the agricultural areas for copper determination and it is hoped that more concrete evidence will be available shortly.

It is felt that copper-containing fertilisers should be used on country deficient and subnormal in available copper. Not only will there be an excellent chance of increasing crop and pasture production but better species of pasture plants, such as subterranean clover, burr trefoil, and Wimmera rye grass, are likely to thrive and the copper content of the pastures will be increased to normal or even luxury level. As a consequence stock will benefit.

Fig 2
MAP
OF
SOUTH WESTERN PORTION OF
WESTERN AUSTRALIA
SHOWING
A MAIN SOIL ZONES
B LOCATION OF DISTRICTS WHERE RESPONSE TO COPPER-CONTAINING FERTILISERS HAS BEEN DEMONSTRATED.
115°
117°
119°
28°
30°
32°
34°
DONGARA
CARON
BUNTINE
WUBIN
DALWALLINU
BALLIDU
BURAKIN
DANDARAGAN
KOOJAN
CADOUX
KOORDA
MUKINBUDIN
OBEN LABERRING
OWERIN
WYALKATCHEM
KUNUNOPPIN
GLENCOE
GINGIN
NINNIVALE
HINDMARSH
MUCHEA
WYOLA
CUNDERDIN
PERTH
CORRIGIN
BULLARING
YEALERING
JILAKIN
WAGIN
DUMBLEYUNG
LAKE GRACE
BUSSELTON
MARGARET RIVER
NORTHCLIFFE
PORONGORUPS
MANYPEAK
DENMARK
YOUNGS SIDING
BORNHOLM
WALPOLE
ALBANY
SCALE
1 INCH = 80 MILES
50 40 30 20 10 0 50 100

The annual application of copper-containing fertilisers does not appear to be highly important if 5 or 10 lbs. of bluestone per acre are used with the first dressing. Such treatments are known to have been effective for several years. Whether small annual applications of copper, say 2 lbs. of bluestone per acre, would result in further increase in growth of subsequent crops cannot be decided until a series of experiments, now in its second year, is completed.

Fig. 1.

A. **Superphosphate.**

Moderate copper deficiency indicated by the bending over of the stalks of wheat on Messrs. McKay Bros.' farm, Wyola.

B. **Superphosphate plus bluestone.**

Normal habit induced by the application of bluestone at the rate of 5 lbs. per acre.

Photos: F. V. Knapp.

6.—ACKNOWLEDGMENTS.

1. The author wishes to acknowledge the assistance of colleagues of the Department of Agriculture in carrying out these experiments. Mr. N. Davenport, Mr. F. V. Knapp, and Mr. W. M. Nunn supervised the planting and harvesting of some of the experiments.

2. Thanks are tendered to those farmers who, often at some inconvenience, assisted in the planting and harvesting of the experiments and supplied data in reply to the questionnaires.

3. The statistical treatment of experimental results was carried out by the Forests Department. Asknowledgment is made to the Chief Draftsman of the Department of Lands and Surveys for the preparation of the sketch map.

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The Centrifugal Cream Separator.

CONSTRUCTION, INSTALLATION, AND MAINTENANCE.

J. T. McNALLY, Dairy Adviser.

With Australia at war the onus is on everyone to do his or her utmost to bring about victory, whether in the fighting forces, munition works, or on the home front. By the care and maintenance of farm machinery the farmer will play a big part in sustaining the efficiency of his farm and in keeping production up to the maximum.

On the dairy farm the importance of the cream separator is well recognised, but it is regrettable to note that the machine does not always receive the care and attention it warrants.

In the following article some hints will be given on installing and the care needed to keep a separator in a first-class condition.

The centrifugal cream separator consists of three main parts—(1) the separator frame, (2) the gear and power attachment, and (3) the bowl with internal devices, supply tank and discharge pans.

(1) The separator frame furnishes the foundation and support of all the important parts of the machine. The base of the frame usually carries the bearing of the spindle which drives the bowl. This bearing is generally fitted with an adjustable screw whereby the bowl may be raised or lowered in the frame, brass bushings are carried at the bottom and top of the spindle, which serve as a guide

to the spindle and keep the bowl from wobbling. The upper bushing is usually equipped with a type of spiral spring to give greater elasticity of movement and this spring needs checking regularly and renewing if necessary.

(2) The driving mechanism falls into two types, hand or power. In the case of the hand separator, the power mechanism is part of the separator proper. The fundamental principle of the mechanism is to produce a high number of revolutions, which are required by the bowl, with a limited number of turns with the crankshaft. This is accomplished by transmission of the power by a series of gear wheels between the crankshaft and the spindle of the bowl. It is obvious that smooth and efficient running can only be maintained if these important parts are kept in first-class condition and renewed if worn or broken. The crankshaft, on practically all modern separators, is fitted with a ratchet or clutch arrangement which guards against shock due to sudden stoppages of the crank. These parts should be kept clean and free from excess oil.

The power drive falls into three classes: belt drives, steam turbine and electric. Belt driven machines are the most commonly met with in this State, and fittings vary from fixed pulleys to various type of clutches. Slight adjustments are necessary at regular intervals, but if the maker's instructions are carried out and the friction surfaces are kept clean, little trouble should be experienced. Belts should be kept tight and free from moisture: under no circumstance should the belts be permitted to become saturated with oil.

(3) The bowl is the heart of the separator. It varies considerably with different types of separators, but the general principles are similar. In the present day separators, the bowl is usually equipped with a series of internal contrivances, the more general type being the cone shaped disc. These discs are studded at intervals with slight projections, or lugs, for the purpose of keeping the discs a slight distance from each other. The upper, or closing, disc is fitted with a sleeve which extends up into the neck of the bowl cover. This disc carries a number of projections on its upper surface to form a narrow space between it and the cover of the bowl. In a number of separators the cream adjustment screw is fitted into this disc, and in others the adjustment is fitted into the bowl cover. These fittings are very important and should be treated as such, usually adjustment is essential about twice in the year.

On most separators in use, the bowl fits into the spindle to which is transmitted the motive power which revolves the bowl. In other machines the bowl is suspended. its spindle at the top of the bowl being coupled to an overhanging spindle head.

The bearing on which the spindle revolves generally consists of a steel point on which a similar point at the termination of the spindle rests, or the spindle may rest on a ball bearing between the points mentioned. These points need renewing at regular intervals.

Supply tank, float and discharge pans are found on all separators; care is necessary in handling these parts as any damage will decrease their efficiency.

When installing a separator the most convenient place in the dairy must be selected and a solid, firm foundation provided. The machine should be set up at dead level; the spindle and bowl are constructed to allow for slight variations off the level, but greater efficiency and longer life are obtained if the dead level is strictly adhered to.

Oil is one of the most important items in the life of the working parts of the separator. Absence of an adequate supply of the proper type oil results in undue wear on the working parts, which may result in misalignment and unsatisfactory

running. Several systems of oiling are in use, but if the maker's instructions are followed strictly, and oil is renewed as advised, more efficient running and longer life to the machine will result.

Too much stress cannot be laid on the importance of cleaning the separator. Many impurities are collected during separation. These are found in the separator slime and consist largely of a viscous nitrogenous matter contained in the milk in addition to dust, dirt, bacteria, etc.—which may have reached the milk during milking. In addition to this, the bowl contains small quantities of milk which, if not promptly removed, will decompose and ferment and cause the metal surfaces to corrode and pit. This damage to the machine not only shortens its working life, but contaminates the cream of succeeding separations with metallic salts, resulting in a low keeping quality of the resultant butter. Another point in the time lapse between the completion of separation and the washing of the machine, is the drying of milk on the exposed surfaces. This milk is difficult to remove, and the assistance of abrasives is sought. The abrasives will remove the accumulations but will also remove the tinning, exposing the more easily corroded metals.

The method of washing which has given excellent results is:—

1. Dismantle machine immediately after separation.
2. Wash off all surplus milk with cold water.
3. Wash all parts with a brush and warm water, to which has been added an alkali or some good washing powder.
4. Steep in boiling water.
5. Place on a clean rack to drain.

When discs become loose in the bowl, the slack can be taken up by the addition of one or two discs; this improves the skimming efficiency.

Should separation not be carried out on the farm for any reason, such as a temporary transfer to whole milk production, all parts of the machine should be thoroughly washed, as previously described, smeared with petroleum jelly and stored in a clean dry place until again required. The frame should be wiped over with an oily rag and protected from moisture.

Berkheya or Hamelin Thistle*

EXPERIMENTS WITH WEED-KILLERS.

G. R. W. MEADLY† and A. B. CASHMORE‡

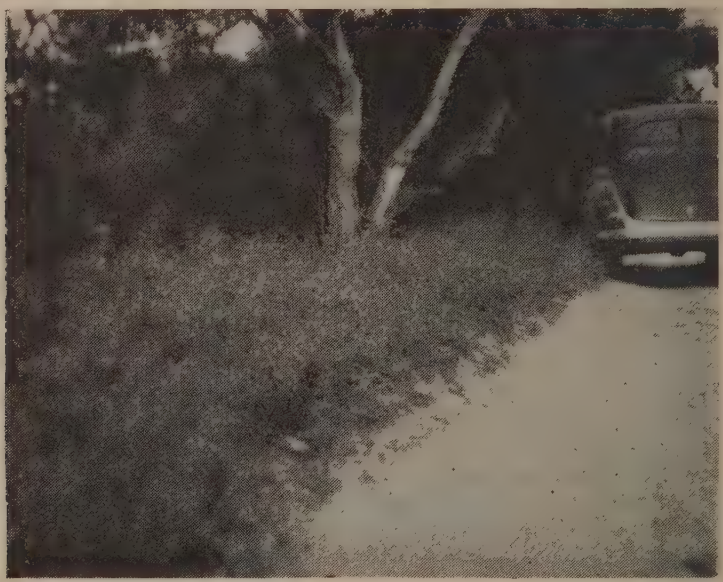
SUMMARY.

Berkheya thistle, native to South Africa, occurs freely over an area of approximately 25 acres at Hamelin Bay in Western Australia and has been recorded in Victoria and South Australia. It is a perennial plant with many undesirable features.

An experiment designed to determine the effects of selected weed killers on this plant showed that 7½ per cent. and 10 per cent. Atlacide and 7½ per cent. sodium arsenite solutions are capable of reducing the density of the stand significantly with a single application.

1. *Introduction.*

Berkheya thistle was first brought to the notice of the West Australian Department of Agriculture in 1909, as shown by a specimen in the State Herbarium with the vague locality of "near Bunbury" on the specimen label. It was doubtless secured from the Hamelin Bay District and presumably was introduced from South Africa, its native habitat, in ballast from timber boats using the Hamelin jetty in the early years of this century. It now occurs on approximately 25 acres of coastal sandy country and has spread along the Karridale road to the fringes of the karri†† formation, which is represented in the main by a light loam soil.



Berkheya Thistle growing along the roadside at Hamelin Bay.

In Victoria, it was recorded from Geelong in 1906, Coode Island in 1908 and Port Phillip in 1909. It appeared in South Australia more recently.

The plant has several undesirable features. It is a free seeding perennial of a spiny nature, the seeds being adapted for mechanical distribution. Although the spread during the last 30 years has been comparatively slow, there is every possibility that the plant could become more aggressive on the better soil types. In South Africa it has been recorded from inland localities as well as the seaboard, thus there is no reason to believe it will remain confined to coastal sandy soils.

As with many other South African plants which have become weeds of consequence in Australia berkheya thistle has not proved troublesome in its native country.

The only information available concerning the control of berkheya thistle is a report by Mr. J. M. Nelson, a dairy adviser of the Department of Agriculture, to the effect that one drum of Atlacide (100 lb.) used on the thistle at Hamelin "appears to have been very effective." Mr. Nelson added that, in his opinion, a

weaker solution could be used successfully. We understand that a 7½ per cent. solution was applied but have no information concerning the rate of application.

As the plant is growing among scrub on steeply undulating country, consisting in many places of loose sand, cultivation is not practicable.

2. *Experimental Procedure.*

The experiment was designed to determine the effects of selected weed-killers on *Berkheya rigida*. The site consisted of an area of densely infested calcareous dune sands at Hamelin Bay. Treatments selected were as follows:—

1. Common salt .. .. 2½ tons/acre.
2. Atlacide .. .. 100 lb./acre—200 gallons 5% solution.
3. Atlacide .. .. 150 lb./acre—200 gallons 7½% solution.
4. Atlacide .. .. 200 lb./acre—200 gallons 10% solution.
5. Sodium arsenite .. 150 lb./acre—200 gallons 7½% solution.
6. Control.

The programme provided for five replications of each treatment using 1 200 acre plots (25 links x 20 links). A reasonably uniform stand of the weed sufficiently large to include five replications of all treatments in one block could not be located and the series were set out in two pairs and a single row. On 20th November, 1940, a dull mild day, the Atlacide and sodium arsenite treatments were applied in the form of a fine spray by means of a knapsack spray pump, while the salt was spread by hand. At the time of application, a large proportion of the plants was commencing to flower, a stage at which chemicals can be expected to produce most satisfactory results when applied to perennial weeds.

An examination on 3rd March, 1941, disclosed that portions of Blocks A and B, representing two series of treatments, had been burnt some short time before and counts were restricted to the remaining three series. The following table summarises the results:—

Treatment.	Mean number of plants per square link.
1. Common salt—2½ tons per acre	0.5
2. 5% Atlacide (200 gallons per acre)	0.1
3. 7½% Atlacide (200 gallons per acre)	0.1
4. 10% Atlacide (200 gallons per acre)	0.1
5. 7½% sodium arsenite (200 gallons per acre) ..	0.2
6. Control	1.1
General mean	0.37
Standard error	0.16
Standard error %	44.0
F	59.01
F @ 0.1	5.64

The figures show no significant differences between chemical treatments, but all are better than the controls. Observation indicated that treatment 3 was generally the best and the plants were very brittle; treatment 2 showed pronounced regrowth and treatment 4 was effective with regrowth just commencing. Treatment 1 was obviously the least effective at this stage. Four of the seven plants counted on treatment 5 were included in one quadrat throw and this treatment appeared very effective on each of the three blocks.

Berkheya Thistle (*Berkheya rigida*).

A. Habit of Plant—$\frac{1}{3}$ natural size.
B. Upper leaf—natural size.
C. Flower head—natural size.
D. Single flower—twice natural size.
E. Achene ("Seed")—twice natural size.

A further series of counts was made on 11th November, 1941, to ascertain any further development of persistent plants or any seedling formation during the winter and spring of 1941. The results are presented below:—

Treatment.	Plants per Square Link. Total.	Persistent.	Seedlings.
1. Common salt	0.74	0.34	0.40
2. Atlacide 5%	0.48	0.34	0.14
3. Atlacide 7½%	0.76	0	0.76
4. Atlacide 10%	0.04	0.04	0
5. Sodium arsenite 7½% ..	0.20	0.10	0.10
6. Control	1.34	1.12	0.22
General mean	0.59	0.32	0.27
Standard error	0.25	0.20	0.23
Standard error % ..	42.37	63.06	85.19
F	3.42	4.29	1.46
F @ .01	4.10	4.10	4.10

An analysis of the table shows that there were no significant differences between treatments in terms of total plants (persistent plants plus seedlings) or of seedlings, but all chemical treatments were effective in reducing the density of persistent plants. The most effective treatments were 7½ per cent. and 10 per cent. Atlacide and 7½ per cent. sodium arsenite. The development of seedlings was sporadic and their non-appearance on the 10 per cent. Atlacide plots was probably due to temporary soil sterilisation rather than to any effect of the chemical on seed viability. *Berkheya rigida* occurs in aggregations and not as a uniformly distributed stand, a condition which is reflected in the high variability of the figures.

3. *Conclusions.*

The experiment has proved that 7½ per cent. and 10 per cent. Atlacide and 7½ per cent. sodium arsenite are capable of considerably reducing the stand with a single application. An organised programme carried out over a period of a few years should result in virtually eliminating this weed.

The effects of an accidental fire on portion of the experimental site indicate that spraying followed by burning gives better results than spraying alone.

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* *Berkheya rigida* (Thunb.), Hutch., and Burt-Davy. For a description see A New Noxious Weed—C. A. Gardner, *Journ. of Agric.*, W.A., Vol. 6, No. 1. † Weeds Officer, Department of Agriculture. ‡ An officer of the Division of Plant Industry, Council for Scientific Research. †† *Eucalyptus diversicolor* F. Muell.

Green Manures and Compost.

VALUABLE FERTILISERS FOR HOME GARDENS.

SOME INTERESTING ANALYSES.

G. H. BURVILL, Assistant Plant Nutrition Officer and
L. T. JONES, Agricultural Adviser.

Because of the shortage of mineral fertilisers due to war conditions it is necessary for farmers, orchardists and home gardeners to consider other sources of fertilising materials. Animal and poultry manures are widely used especially for growing vegetables and flowers in market and home gardens, but transport and labour difficulties have made these more difficult to procure. Green manures and composts, since they are grown or made more or less on the spot, have a special significance in these circumstances. As some guide to the manurial value of these materials, analyses have recently been made of green manure crops and of compost prepared under suburban backyard conditions.

Green Manures.

This term is applied to crops grown for the purpose of being dug in, or ploughed under, while still green and sappy. Such material decomposes in the soil and the nitrogen, phosphorus, potassium and other elements which the crop has mobilised during its growth, are gradually released, so that they may benefit succeeding crops, or in the case of orchards and vineyards, the adjacent trees and vines. Leguminous plants such as peas, tick beans, lupins, vetches and clovers are especially valuable for green manures because they are able to absorb nitrogen from the air as well as from the soil, provided they have suitable strains of nitrogen fixing bacteria in the nodules on their roots.

The New Zealand blue lupin (*Lupinus angustifolius* D.C.) can be grown as a green manure crop during the winter months around Perth and is sometimes used in orchards and vineyards throughout our fruitgrowing areas. Samples of this plant were taken for analysis at the flowering stage in the latter part of August when they were considered ideal for turning under as green manure. Estimates of the yields were made and analyses for nitrogen, phosphorus, potassium and total ash carried out on the tops and the main roots pulled with the plants. Details as follows:—

Sample 1.—Grown on sandy soil surrounding a young lemon tree in a suburban garden at South Perth. The area was not previously manured but received approximately 2 ozs. per square yard (600 lbs. per acre) of superphosphate when the lupins were planted the first week in April. The seed was inoculated with a culture of the root nodule bacteria before planting*

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* For further information on this important subject see the following leaflets by W. P. Cass Smith, obtainable from the Department of Agriculture:—

No. 323A. Directions for using pure cultures of nitrogen fixing bacteria for the inoculation of leguminous seeds.

No. 699. Conserve nitrogenous fertilisers by growing inoculated legumes,

No. 679A. The inoculation of New Zealand lupins in relation to green manuring practice.

Sample 2.—From an area of chocolate fine sandy loam (alluvial soil) near the Swan River at "Belhus," Upper Swan. This is a crop and grazing paddock and has grown excellent stands of New Zealand blue lupins during the past three years. It received no fertiliser this year.

	Sample 1. South Perth.		Sample 2. Upper Swan.	
Yield of Green Material—				
Tons per acre	35·9		18·8	
Pounds per square yard	16·6		8·7	
Height of crop when sampled (inches)	36–42		36	
Moisture, per cent. of original sample	86·0		85·1	
Tops (dry), per cent. of original sample	12·0		13·1	
Roots (dry), per cent. of original sample	2·0		1·8	
Nitrogen (N)—	Tops.	Roots.	Tops.	Roots.
Per cent. of oven-dried material	2·53	2·04	2·71	1·87
Pounds per acre	244	33	149	14
Equivalent weight of sulphate of ammonia (20 per cent. N):				
Pounds per acre	1,385		815	
Ounces per square yard	4·6		2·7	
Phosphorus (P)—				
Per cent. of oven-dried material	0·22	0·17	0·18	0·12
Pounds per acre	21·2	2·7	10	0·9
Equivalent weight of superphosphate (22 per cent. P_2O_5):				
Pounds per acre	249		114	
Ounces per square yard	0·82		0·38	
Potassium (K)—				
Per cent. of oven-dried material	0·63	0·39	2·66	2·13
Pounds per acre	61	6·3	147	16
Equivalent weight of sulphate of potash (48·6 per cent. K_2O):				
Pounds per acre	167		404	
Ounces per square yard	0·55		1·3	
Total Ash—				
Per cent. of oven-dried material	5·68	5·10	8·35	6·48

Chemical analyses made in Government Chemical Laboratory, Perth.

In the above data are shown the amounts of sulphate of ammonia, superphosphate, and sulphate of potash containing the same amounts of N, P, and K as the green manure crops. It is obvious that the ploughing in, or digging in, of New Zealand blue lupins adds a large quantity of nitrogen to the soil and also returns to the surface layers very valuable amounts of phosphorus and potassium. These become available to succeeding crops, though less quickly than would the N, P, and K of sulphate of ammonia, superphosphate, and sulphate of potash. Even much lower yields—say 10 tons per acre of green material—would add very useful amounts of N, P, and K.

The effect of a liberal superphosphate dressing is shown in the higher phosphorus content of sample 1. The much greater potassium content of sample 2 must indicate that the alluvial soil at Upper Swan contains much more available potassium than the sandy soil at South Perth. A further important point is that, except for nitrogen, the composition of a green manure crop will depend on the soil on which it grows and the fertilisers applied to it, or previously used on the area.

Compost.

Compost is material prepared for manurial purposes in a heap or pit from various forms of waste materials such as crop wastes, straw, old garden plants, weeds, soft prunings, lawn mower cuttings, small amounts of animal and poultry manure, ashes and soil. Such materials are wetted and rotted for several months before use. The addition of small amounts of lime and superphosphate assists the process. Full information on making composts is contained in Leaflet No. 671, obtainable free on application to the Department of Agriculture.

The labour and cartage involved prevent the making and use of compost in a big way on farms in this State, but every home gardener should have a compost pit or heap, especially to provide humus and nitrogen for the vegetable and flower gardens.

Compost prepared in a heap in a suburban garden from old plants and soft prunings, lawn cuttings, poultry yard scrapings (four fowls), superphosphate, slaked lime and a small amount of loamy soil has been analysed to provide the following data:—

1 petrol tin (4 gallons = 2/3 cubic foot) of moist compost loosely packed weighed 33 lbs. and spread over one square yard, formed a layer 1-1½ inches thick. Such a dressing would equal 71 tons per acre. One cubic yard loosely packed would weigh 1,320 lbs.

Composition.

All data refer to the moist compost.

	Per cent.	lbs. per ton.
Moisture	38	...
Total ash (mostly sand from poultry yard scrapings)	54	...
Acid soluble ash	1	...
Nitrogen (N)	0·27	6·0
Phosphorus (P)	·11	2·5
Phosphorus as P_2O_5	·25	5·6
Potassium (K)	·04	0·9
Potassium as K_2O	·05	1·1
Calcium (Ca)	·47	10·5

Analyses made in Government Chemical Laboratory, Perth.

These data may be compared with animal manures, for compost somewhat resembles rotted manure in appearance and is used in the same way in the garden. Many analyses of horse and cow manure have been published, but most refer to manure collected from stables under conditions where the urine is soaked up by the solid manure and bedding of the animals. If the urine is lost, about half the nitrogen and over half the potassium voided by the animal are lost, but nearly all the phosphorus is in the solid faeces. Cow manure, for instance, as obtained by home gardeners around Perth, is more likely therefore to equal in composition yard manure, for which Salter and Schollenberger in Ohio Agricultural Experiment Station Bulletin 605 (1939), give the following data:—

	Yard Manure 75-80 per cent. Moisture.	Moist Compost.
Nitrogen (N) lbs. per ton	7·5	6·0
Phosphoric Acid (P_2O_5) lbs. per ton	5·3	5·6
Potash (K_2O) lbs. per ton	3·1	1·1

The figures for the moist compost under discussion show less potash than the yard manure, but comparable amounts of nitrogen and phosphoric acid. The heap contained no ashes which would have raised the potassium. Had the compost contained less sand it would have shown much higher figures for N, P, and K.

Using such compost for digging-in at one petrol tin (4 gallons) per square yard or 71 tons per acre, it would add to the soil the following amounts of nitrogen, potassium and phosphorus.

	Pounds per acre.	Ounces per square yard.
Nitrogen (N)	430	1·4
Equivalent of sulphate of ammonia (20 per cent. N)	2,150	7·0
Phosphorus (P)	176	0·6
Equivalent of superphosphate (22 per cent. P_2O_5) ...	1,830	6·3
Potassium (K)	63	0·2
Equivalent of sulphate of potash (18·6 per cent K_2O)	157	0·5

As in the discussion of the green manures it is not intended to imply that the compost will have the same manurial value as the calculated amounts of sulphate of ammonia, superphosphate, and sulphate of potash shown above. If the N, P, and K of the compost are only one-half, or one-third, as readily available as in the mineral fertilisers, the compost is still a very valuable source of these elements. Further, the humus added in the compost will improve the moisture holding capacity and general fertility, especially on the sandy soils of the Perth suburban areas.

A fine mixed green manure crop of New Zealand blue lupins and tick beans growing on sand in a backyard at South Perth. The fence behind the crop is 6 feet high. The method of digging-in such a crop is clearly shown in the picture. The crop from the soil about to be dug has been pulled up and laid in the trench and will be buried by turning over the soil. At the same time a trench to receive further green crop is opened up.

—Photo by W. P. Cass Smith.

Legume Inoculation.

TESTS WITH BLUE BOILER PEAS AND NEW ZEALAND LUPINS.

W. P. CASS-SMITH, Plant Pathologist,

H. L. HARVEY, Assistant Plant Pathologist.

The advantages to be obtained by the pre-planting inoculation of leguminous seeds have been stressed at various times by this department. In certain circumstances yields may be substantially increased by inoculation and in the case of green manure crops large additional amounts of nitrogen and humus-forming materials may be supplied to the soil. The legumes include vegetables such as beans and garden and canning peas, green manure crops such as lupins, field peas and tick beans, and pasture crops such as clovers, lucerne, etc.

Members of this family of plants are not dependent on artificial nitrogenous fertilisers such as sulphate of ammonia and blood and bone because they have the power of obtaining their nitrogen requirements from the air. However, this is possible only if effective strains of nodule-forming bacteria, as opposed to ineffective strains, are present in the soil in which the plants are to be grown. When planting on new land therefore, or on land where similar legumes have not previously been successful, pre-planting inoculation is a wise precaution.

From time to time field experiments are conducted to test the continued effectiveness of the pure cultures issued to growers and to determine whether new strains isolated locally or obtained from other institutions elsewhere can replace them with advantage.

BLUE BOILER PEAS.

This season three strains of nitrogen-fixing bacteria were tested at Pickering Brook on blue boiler peas. They are referred to as A, B, and C. An untreated control is referred to as D. These four rows were replicated five times and the experiment took the form of a randomised block. The rows were 66.6 links long and 4 links apart, and each contained 132 seeds. Superphosphate was applied at the rate of 4 cwt. per acre on each half row and basic super on each remaining half at the same rate. The planting was made 15th May, 1942, on newly cleared land, which was a poor gravelly sand.

A few weeks after germination all five of the C rows were conspicuous by their darker green colour. Thereafter their better growth and colour became more and more marked while the D rows, having reached a maximum height of 6-9 inches, showed a tendency to die off. The A and B rows, while showing fairly good growth and yield, were inferior to the C rows. The rows were harvested 6th October, 1942, and samples taken at this time were later submitted to the Government Analyst for moisture and nitrogen determination. No differences occurred between the half rows which received superphosphate and those which received basic super. See Table 1.

From the table it will be seen that the five C rows gave by far the highest green yields at harvesting, being some 14 *times greater than the five uninoculated D rows.* The A and B rows, though superior to D, were not as good as C.

The nitrogen content of each treatment is also presented together with the equivalent quantities of sulphate of ammonia which these would represent. In this connection the five C rows are again outstanding. The culture used on the C rows was received some years ago from the Waite Institute, South Australia.

Table 1.

BLUE BOILER PEAS.

Treatments.	Green Weight (5 rows).		Moisture.	Nitrogen on dry wt.	Nitrogen.	Nitrogen as Sulphate of Ammonia.
Inoculated—	lbs.	%	%	%	lbs.	lbs.
Strain A ...	12·0	460	71	3·04	0·10	0·47
„ B ...	9·3	356	72	3·10	0·08	0·37
„ C ...	38·5	1,470	76	3·28	0·30	1·41
No Inoculation D	2·6	100	72	3·56	0·03	0·14

NEW ZEALAND LUPINS.

It is also considered worth reporting the results of a trial with New Zealand lupins planted on new land adjoining the above experiment at Pickering Brook, together with some yield and nitrogen figures obtained from a farmer's crop of New Zealand lupins at Parkerville.

At Pickering Brook one row of New Zealand lupins was inoculated with the same strain of bacteria used in previous experiments in 1941* while a check row was left untreated. Row length and spacing was the same as in the adjacent pea experiments but only 88 seeds were planted in each row. Owing to lack of space, replications could not be included. The purpose of the trial was to see if the culture was still as effective as it was in the original experiment last season and in this it succeeded admirably. The inoculated row gave a green yield 12½ times greater than the uninoculated row when harvested on 6th October, 1942, in the early flowering stage.

Yields and nitrogen content are presented in Table 2.

Table 2.

NEW ZEALAND LUPINS—PICKERING BROOK.

——	Green Weight (tops).		Moisture.	Nitrogen on dry wt.	Nitrogen.	Nitrogen as Sulphate of Ammonia.
	ozs.	%	%	%	ozs.	ozs.
Inoculated Row	136	1,240	82·2	2·92	0·71	3·35
Control Row ...	11	100	76·5	2·12	0·05	0·26

On Mr. Brindle's property, Parkerville, a very successful crop of New Zealand lupins was grown this season for green manuring purposes. New Zealand lupins had never been grown here previously as Mr. Brindle formerly considered that they would not thrive in his district. The land which

had been cleared two years was red sandy loam and gravel, which in the virgin state carried red gum, jarrah, and blackboy, and it had been cropped twice with swedes.

An excellent crop of New Zealand lupins grown by Mr. J. Brindle, of Parkerville. This land had never grown legumes previously but following on the inoculation of the seed prior to planting, an estimated green yield of 20 tons per acre was obtained, which contained the equivalent of 712 lbs. of sulphate of ammonia per acre in terms of nitrogen.

The New Zealand lupins were inoculated with pure culture and sown at the rate of 1½ bushels per acre during the second week in April. No fertiliser was applied at planting time as Mr. Brindle considered the residual soil fertility from previous manuring would be ample for crop growth. However, when six weeks old, growth was very stunted and a topdressing of 5 cwts. per acre of super was applied. From then on the crop made remarkable progress as will be seen in the photograph.

On 23rd September, 1942, when flowering was general and just before the crop was ploughed under the soil, samples were obtained for estimation of the green yield and analysis of nitrogen content.

Five samples, each of one square yard were taken, totalling 45 lbs. green weight, and a sample of roots was also obtained by digging up all the roots in the first square yard cut for tops. From Table 3 it will be seen that the nitrogen which would be ploughed under with this crop is equivalent to approximately 6½ cwts. sulphate of ammonia per acre, and there is every possibility that this yield would have been higher had the superphosphate been applied at sowing time rather than during growth.

TABLE 3.

NEW ZEALAND LUPINS—PARKERVILLE.

—	Green Weight from 5 sq. yds.	Green Yield.	Moisture.	Nitrogen on dry wt.	Nitrogen.	Nitrogen as Sulphate of Ammonia.
		tons per acre.	%	%	lbs. per acre.	lbs. per acre.
Tops ...	45 lbs.	19	86·3	2·28	136·0	638·0 } 712
Roots ...	1 lb. 13 ozs. (one sq. yd.)	...	86·2	1·30	15·7	74·0 } lbs.

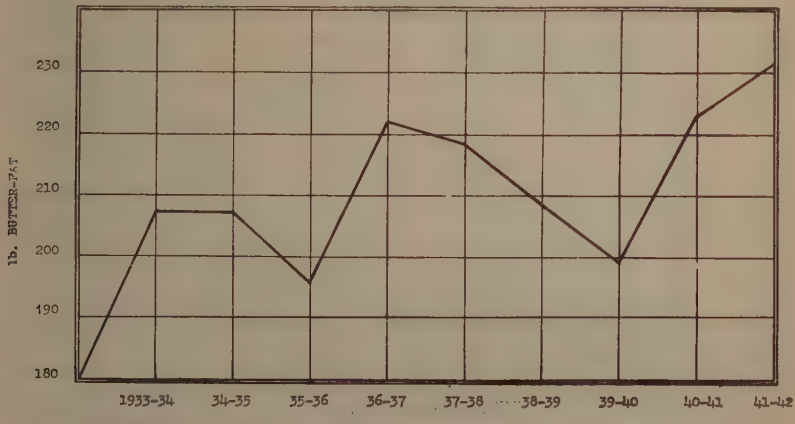
* Cass Smith, W. P., 1942. The Inoculation of New Zealand Lupins in relation to Green Manuring Practice. *Journal Dept. of Agric., W.A.*, 2nd Series, 19, 52–56.

Grade Herd Recording.

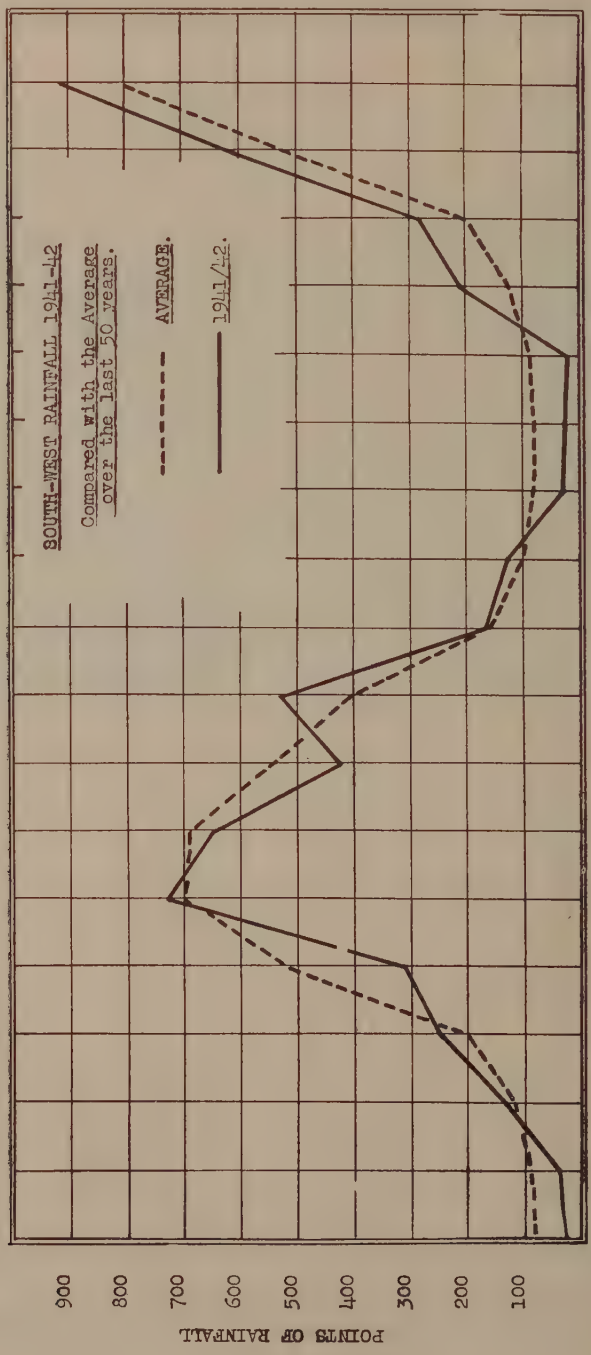
M. CULLITY and R. A. PAUL.

In compiling the report for the year 1941-42 for Grade Herd Recording in Western Australia an effort is made to survey the general results which have been obtained since the inception of the scheme in 1933, as this will be the final report until after the cessation of hostilities. A variety of difficulties beset the operation of the units during the year and not the least was the impossibility of obtaining suitable recorders, who would not be liable for military training. As a consequence it was decided to cease recording as from the 31st March until such time as normal conditions return.

Despite some factors militating against increased production the seasonal conditions were so favourable that improved averages were returned from all units. Good rains fell in March and April, 1941, effecting excellent germination and giving pastures an early start. Growth was slowed up to some extent during the wet winter months, due to excessive moisture in the soil, but falls well in excess of the average during September and further showers up to the end of November gave a long and prolific growing season. However, the season finished abruptly and the remainder of the year was abnormally dry.



Graph showing the trend in average butter-fat production since the commencement of Grade Herd Recording.


SOUTH-WEST RAINFALL 1941-42
Compared with the Average over the last 50 years.
AVERAGE.
1941/42.
POINTS OF RAINFALL
900
800
700
600
500
400
300
200
100
JAN'41 FEB MAR APL MAY JUN JUL AUG SEP OCT NOV DEC JAN'42 FEB MAR APL MAY JUN

In view of the above, it would be expected that an appreciable increase in the average production per cow would be shown—this was anticipated in last year's report.

Table 1 shows that the average production increased 25 lbs. over all units, or nearly 33 lbs. when four units, which for various reasons had to discontinue operations earlier than anticipated, are excluded. The units at Capel and Benger were closed at 31st December, 1941, and it was found possible to test only a few herds in the Vasse and the Serpentine units after that date.

The unsettled conditions have had an adverse effect on the farmers' outlook to testing, and it is believed that this has been responsible for preventing improvement in some herds.

It will be noted from the table that the number of cows tested is the lowest for six years. This is accounted for by the fact that only 16 units commenced testing in May, 1941.

TABLE 1.

AVERAGE PRODUCTION PER COW, 1934–42.

Year.	No. of Cows.	Milk.	Test.	Butter Fat.
		gals.	%	lbs.
1933–34	4,038	415	4·35	180·6
1934–35	4,088	456	4·56	207·8
1935–36	4,590	459	4·51	207·3
1936–37	9,115	434	4·53	196·7
1937–38	10,033	486	4·59	223·1
1938–39	12,368	487	4·48	218·7
1939–40	11,479	462	4·51	208·3
1940–41	9,609	447	4·45	199·0
1941–42	7,081	496	4·52	224·02
	5,695	502	4·61	231·78*

* Excludes four units which were tested for from six to seven months only.

An examination of Table 1 will show the trend in production since the commencement of the scheme in 1933-34. In that year eight units were tested for an average production of 415 gallons of milk and 180.6 lbs. of butter-fat. An improvement was recorded in the succeeding year and maintained in 1935-36, when one additional unit was started. However, in 1936-37 new units commenced operations and the average for all cows tested fell to 196.7 lbs. of butter-fat. It is interesting, however, to note that the nine new units averaged only 181.4 lbs. of butter-fat and the older units 210.1 lbs.

One additional unit in 1937-38 and six in 1938-39—bringing the total to 23 (two others ceased testing) did not cause a decline in production as the excellent season and pastures which were available were conducive to production. In the former year a record production of 223.1 lbs. of butter-fat was achieved, but the older units again had a higher average of 229.6 lbs. The general average declined to a small extent in the following year, which was also a good season. This fall was probably due to the inclusion of an additional six units, causing a rise of 2,335 in the number of cows tested. It is interesting to note, in this connection, that the units tested for the first time, with the exception of two, were lower than 190 lbs. in butter-fat average, viz.: 184.7 lbs., 250.3 lbs., 188.9 lbs., 180.9 lbs., 195 lbs., and 164 lbs.

The effects of two adverse seasons can be seen during the following two years when average production declined to 208.3 lbs. and then to 199.0 lbs., the lowest result since the first year of testing.

The low result in that season may safely be attributed to the very poor feed supplies which were available to the stock. Small reserves had been carried over from the previous season and pastures were short.

As stated previously, the season 1941-42 was extremely satisfactory as ample feed as pasturage and hay was available, and so despite the inclusion of four units the results of which could not be considered a satisfactory index to production owing to the impossibility of testing for more than seven months and despite difficulties created by changes of recorders in several units during the year, the record average of 496 gallons of milk and 224.02 lbs. of butter-fat was established. When these four units are excluded the average for the remainder reaches the still higher level of 502 gallons of milk and 231.78 lbs. of butter-fat.

A study of Table 2 shows that considerable improvement in unit averages was recorded by all units other than Serpentine and Benger. It has been explained already that the production in these units could not be taken as a true reflection of production for a full year.

TABLE 2.

PRODUCTION PER COW IN EACH UNIT.

(Units listed in order of merit.)

Unit.	No. of Herds.	No. of Cows.	Percentage of Heifers.*	Milk.	Test.	Butter Fat.	
						1941–42.	1940–41.
				lbs.	%	lbs.	lbs.
H. Balingup ...	18	477	35	5,706	4·53	258·46	219·61
X. Cowaramup ...	18	339	20	5,409	4·72	255·12	202·88
C. Cookernup ...	21	620	38	5,509	4·55	250·76	218·50
A. Donnybrook ...	20	389	33	4,858	4·96	241·10	202·68
E. Brunswick ...	18	374	49	5,161	4·61	237·94	236·48
I. Forest Grove ...	21	562	30	4,940	4·67	230·90	212·66
U. Metricup ...	24	397	21	4,779	4·71	227·62	201·44
S. Albany	23	473	34	5,025	4·52	227·28	195·11
P. Pinjarra † ...	19	305	...	4,877	4·59	223·95	190·79
F. Dardanup ...	19	533	45	4,675	4·75	222·15	199·02
D. Harvey	25	623	37	4,947	4·38	216·84	200·32
M. Manjimup ...	22	603	21	4,663	4·74	210·92	178·21
B. Serpentine ...	13	231	37	4,769	4·28	204·16	222·24
G. Capel †	12	406	...	5,025	3·96	198·89	187·26
L. Vasse	16	339	34	4,643	4·07	185·06	177·42
O. Benger † ...	12	410	...	4,033	4·22	170·28	187·52

* Includes cows two and three years old. † No. of heifers not available.

It is interesting to note that of the leading five units, four have been in the recording scheme since 1933, while the fifth unit, Cowaramup, has been under test for four years only, having commenced during the 1938-39 season when its average production was 195 lbs. only. Thus an increase of 60 lbs. of butter-fat has been achieved in four years.

Considerable variation in production has occurred in several units from year to year which has been caused by frequent changes in the herds which have been

submitted for test. It should not be necessary to emphasise that it is only from continuous testing that farmers can get the maximum benefit from the testing of their herds.

Table 1 demonstrates the increase in the average production of cows in the scheme. Table 3 sets out the herds grouped according to production and serves as a further demonstration of the improvement which has been achieved. In 1933-34, 74.5 per cent. of the herds produced less than 200 lbs. of butter-fat, while during 1940-41, when the average declined seriously owing to the adverse season, the number of herds failing to reach this level had declined to 53.0 per cent. During the season just closed, only 26.2 per cent. of the herds failed to produce more than 200 lbs.

Studying the higher producing herds in the same table, it is seen that only 5.2 per cent. of the herds produced more than 250 lbs. in 1933-34. In the past season the number reaching this level was 31.7 per cent. of the total herds.

TABLE 3.

HERDS GROUPED ACCORDING TO PRODUCTION.

Butter Fat per head (lbs.).

Year.	350–400.	300–350.	250–300.	200–250.	150–200.	100–150.	Under 100.
	%	%	%	%	%	%	%
1933–34	...	1·3	3·9	20·3	53·6	18·3	2·6
1939–40	...	3·2	18·5	34·6	32·9	9·7	1·1
1940–41	...	1·5	13·9	31·8	39·4	12·7	·8
1941–42	1·6	8·2	21·9	42·1	21·5	4·7	...

An analysis of production of the individual cows is found to indicate a similar result.

In Table 4 all cows are grouped according to production and whether they are cows or heifers. All animals under three years of age at calving are treated as heifers. A substantial improvement in comparison with previous years is shown.

TABLE 4.

COWS GROUPED ACCORDING TO AGE AND PRODUCTION.

(Cows tested less than 90 days excluded.)

Groups according to Butter Fat Production (lbs.).

Age.	Over 600.	500–600.	400–500.	300–400.	200–300.	150–200.	100–150.	Under 100.	Total Cows.	Year.
	%	%	%	%	%	%	%	%		
Mature	...	...	0·9	11·1	45·5	24·2	13·5	4·8	6,447	1941
Do.	0·02	0·3	2·4	21·8	46·4	17·4	8·7	3·0	4,287	1942
Junior	...	...	...	3·0	28·4	28·5	26·9	13·2	3,162	1941
Do.	...	0·05	0·2	5·8	36·9	27·5	20·2	9·4	1,978	1942

One feature which merits mention at this stage is the relatively high proportion of young cows, approximating 30 per cent., which have been entered for test. It is possible that a number of animals will have calved for the second time before they reach the age of three years, but it is not considered that these are numerous. A survey carried out in the Brunswick district, together with two years' collections of details of herd wastage in this scheme, indicate that the rate of wastage is between 15 per cent. and 20 per cent. per annum. Accordingly, it may be concluded that the high proportion of young cows is due to farmers increasing the size of their herds.

A number of farmers—while they have increased the average production of their herds—have also improved the carrying capacity of their farms and so have produced considerably more butter-fat from their properties. Of these, Mr. G. E. White of Balingup provides an excellent example.

TABLE 5.

Year.	Cows.	Average Butter Fat per Cow.	Total Butter Fat.
	No.	lbs.	lbs.
1933–34	26	183	4,758
1934–35	35	188	6,580
1935–36	38	155	5,890
1936–37	50	196	9,800
1937–38	39	258	10,062
1938–39	52	259	13,364
1939–40	48	203	9,744
1940–41	57	234	11,934
1941–42	48	240	11,520

Reference has been made in some previous reports to the results obtained by Mrs. D. B. Rose of Burekup. Table 6 shows the record of this herd over seven years. During the first two years of testing the owner became impressed with the fact that the property was over-stocked with milking cows and began to reduce the number. It will be noticed that the greatest total production from the farm has been obtained with the smallest number of cows.

TABLE 6.

Year.	No. of Cows.	Butter Fat.	
		Average.	Total Production.
		lb.	lb.
1935–36	70	185·1	12,957
1936–37	62	210·8	13,072
1937–38	51	293·9	14,992
1938–39	50	317·7	15,887
1939–40	53	275·3	14,589
1940–41	54	286·7	15,482
1941–42	56	231·2	12,945

Unsettled conditions regarding labour and, possibly, a gradual expanding herd have been responsible for a decline in total output.

The information given in the foregoing pages shows that a very substantial improvement in production has been obtained during the operations of the Grade Herd Recording Scheme. It now remains to be shown how this improvement has been achieved and to suggest means whereby herds may be maintained, at least until it is again possible to re-institute a system of recording.

Reverting to Table 4, it has been shown that the quality of young stock is better than some years ago. These young stock are bred from the original cows mated to pure-bred bulls in 87% per cent. of the herds. That this improvement of quality of young stock has been obtained is a vindication of the policy of using pure-bred standard bulls.

In the absence of an opportunity of procuring proved good bulls, farmers have had no option but to buy sires on the only evidence available, i.e., that they were pure-bred and from high producing stock.

It is on this basis that herd improvement work has been carried out in Western Australia. The number of pure-bred sires has increased consistently over the past 16 years and at the same time the average production of milk per cow in the State has also improved.

Again this year, a further list of bulls who have sired more than six heifers producing over 250 lbs. of butter-fat, is included. It is hoped that on the resumption of testing after the war that the basis of proving sires will be strengthened and farmers given the opportunity of selecting bulls, not only on their breeding and production backing, but also on the actual performance of their daughters.

TABLE 7.

ADDITIONAL LIST OF PROVED BULLS.

Name of Bull.	No. of Daughters.	Average Butter Fat Production.	Unit.	Owner or Late Owner.	Age of Bull.
Australian Illawarra Shorthorn—					Years.
Starlight of Wongong	11	317·35	Albany ...	F. Pease ...	Dead.
Glanavon Percy ...	10	226·25	Albany ...	Mrs. L. Faulkner & Sons	Dead.
Brackenhurst Gibson's Champagne	13	279·08	Balingup ...	S. C. Maidment ...	7
Beauna Vista Musket	9	227·22	Vasse ...	H. Carter ...	8
Jersey—					
Avon Court Magnet	17	262·10	Vasse ...	H. S mmens ...	Dead.
Guernsey—					
Rutherwood Rose Chief	6	256·33	Albany ...	Farr Bros. ...	6

The advisability of keeping in use bulls which sire daughters of high productive capacity cannot be stressed too greatly. Investigations in other countries in recent years have shown that far too great a percentage of sires are actually

lowering the production of herds. It is being demonstrated repeatedly that a large proportion of bulls which have sired high producing daughters have been sold for slaughter before it was realised that they were of exceptional value. This experience has been met with in this State, as most of the bulls, the names of which have been published in the lists of proved bulls, have been discarded before their worth was realised.

The use of good sires may be largely wasted if proper selection and care of the heifers which are to join the herd is not made. Some reference has been made in previous reports to the results obtained with heifers in the Brunswick unit. The average production of three heifers owned by Messrs. A. F. Clifton & Co., which won the S. A. Mitchell Cup in 1937-38 is interesting. These cows have produced particularly well in each year since, and for the past three years have been the leading cows in the herd. Their average productions are shown hereunder:—

	lbs. Butter-fat.
1937-38	318.17
1938-39	375.81
1939-40	375.72
1940-41	414.25
1941-42	397.70

During the past season this competition, for which a trophy was presented by Messrs. Browne's, Ltd., was won by J. Hartley, with the following three heifers, the progeny of one bull:—

	lbs. Butter-fat.
Marlene	376.6
Blondie	360.66
Merle	339.85
Average	359.03

It would not have been possible for these results to have been obtained if proper care of the young heifers had not been practised.

Feeding.

It is a truism that good stock cannot produce to their maximum without adequate feeding. However, it is apparent that a very great proportion of the herds do not receive full feeding, as is shown by the fluctuations in production which follow good and bad seasons, which are really seasons when there is ample or low supplies of feed.

The depressing effect on production of poor seasons has been avoided in many herds by the conservation of plentiful supplies of hay and silage, which have been available for use during the summer, autumn, and early winter. In this way it has been possible to satisfy the cows with ample quantities of high quality roughage allowing a reasonable flow of milk. The utilisation of the conserved fodder at the break of the new season, during the period of the first rains and for some weeks thereafter, affects the production usefully for the remainder of the season. Where inadequate use of hay or silage is made, the cattle must have access to pasture for the whole period while the pasture plants are germinating and making their early root growth. Some grazing, which cannot be avoided in these circumstances, will

retard the development of the plants both in root and top growth and they are never able to recover fully as the cold and wet winter quickly sets in, stopping all growth.

Where full feeding of conserved fodder is carried out it may be possible to keep the herd from pasture for several weeks, allowing rapid growth with full root development. Once this is obtained and grazing regulated, there usually is plenty of grazing for the remainder of the season, and it will be found that a much more rapid response after grazing will be obtained.

The improvement of pastures is a further means of increasing production. The inclusion of a good grass species such as perennial rye grass in the clover pastures will allow a great increase in carrying capacity.

Even where it is not possible to introduce improved species, a better utilisation of pasture can be obtained by the control of grazing. This, however, cannot be effected without greater subdivision of most farms.

It is suggested that the ideal should be sufficient paddocks to allow daily, or at least alternate day changes of stock, and to allow each paddock to be closed for a month between grazings.

In this way the pastures will be allowed to make good growth before being grazed, and the stock will always be moving into good feed. It is advisable also that pastures should not be grazed too closely as this will tend to delay the rate of regrowth.

Culling.

The use of good bulls may not be a great advantage unless care is taken in selecting the best of the progeny. In other words, the worst of the cows should be discarded as soon as sufficient replacement heifers—the progeny of the better cows—are available.

The rigid application of the rule that all cows which failed in each of two successive lactations to produce 150 lbs. of butter-fat should be culled was not necessary, as most farmers were only too anxious to dispose of their low producers.

While grade herd recording is in abeyance it will not be possible to give farmers the exact information regarding the production of individual cows. Therefore, if culling is to be continued some basis is necessary for deciding which cows should be sold.

For the immediate future, of course, the records of production for last year and the previous years will provide direct information on which culling can be effected, but if testing is not re-instituted for some years, the information on the records, if studied correctly, will be found to give a deal of other data.

It is suggested that these records should be examined closely now by segregating the cows in the herds into families. In every herd will be found several series of cow, dam, great dam, etc., and it will be shown that a number of these series will all have good production figures; others will have variable figures—some good, some indifferent, some poor—and yet other series will have all low productions. Concentration on the better group for replacement heifers and on the poorer group for cullings in the absence of more direct information, will prove a most useful method. Of course, there will be the usual number of cows which will be subject to culling for more obvious reasons, such as disease, sterility, etc. In his examination of the various families in the herd it would be useful if the farmer

also kept in mind his knowledge of the inclination of individual cows to disease, such as mammitis, as he may find that certain families are more susceptible than others. This may make them more suitable subjects for culling.

Month of Calving.

Data published in the reports of the grade herd recording scheme during the past few years has shown that there is an optimum period for cows to calve. Cows calving in this period produce more than those who calve in other periods of the year. Again, during the last testing year, the conclusions set out in previous reports have been confirmed. In Table 7 is shown the average production of the cows according to the month in which they calved for the season 1941-42, and for the six years since this information was prepared first.

TABLE 8.

PRODUCTION OF COWS ACCORDING TO MONTHS OF CALVING.

Month of Calving.	Average Butter Fat, Year 1941–42.	Average 6 years 1936–42.
	lb.	lb.
January	243·5	190
February	246·8	205
March	269·0	223
April	269·0	241
May	275·3	243
June	256·3	241
July	240·3	235
August	201·2	209
September	174·9	187
October	191·6	184
November	228·7	189
December	251·9	179

It will be seen from an examination of Table 8 that highest production is obtained from those cows which calve between the end of March and the end of July. For cows calving after the latter date there is a considerable and rapid drop in production. It is rather curious to recall that some years ago it was the practice to arrange calving for September and October in order that the cows would have the advantage of plentiful feed at the time of calving. The changes which have followed the use of subterranean clover pastures and the practice of top-dressing with superphosphate, have allowed earlier calving with more profitable results. However, the change to earlier calving was slow, until results from herd recording were available.

On reflection, the fact that early calving assists higher production per annum, is not more than would be expected, as the cows calving with a normal flush of milk, with reasonable care, are able to continue production during the winter months and can give an increased flow with the good pasturage which is available in August, September, October and November.

By that time, a cow which has calved in early April is nearing the end of nine months milking period and the farmer is usually content, when her production declines, to commence drying off in January and February.

Table 9.

COWS COMPLETING LACTATION.

Unit.	Percentage of Cows completing Lactation.*	Butter Fat Average.	Percentage of Cows completing full 273 days.	Butter Fat Average.	Unit. Butter Fat Average.
		lbs.		lbs.	lbs.
Cowaramup	74	267·28	31	320·98	255·12
Brunswick	†	†	29	296·86	237·94
Pinjarra	†	†	27	295·87	223·95
Dardanup	†	†	23	290·97	222·15
Forest Grove	†	†	45	290·79	230·90
Balingup	88	259·80	53	287·09	258·46
Cookernup	66	263·56	49	285·41	250·76
Manjimup	88	214·64	28	283·06	216·92
Albany	47	269·23	33	282·43	227·28
Donnybrook	81	245·18	39	275·20	241·10
Metricup	†	†	18	273·94	227·62
Serpentine	†	†	28	260·44	204·16
Harvey	58	243·92	53	250·42	216·84
Vasse	43	210·04	35	238·98	185·06
Capel	‡	‡	‡	‡	198·89
Benger	‡	‡	‡	‡	170·28
Average all Units ...	...	...	38	279·70	...

* *i.e.*, 273 days, or drying-off naturally in a lesser period. † Not available.
‡ Tested seven months only.

In Table 9 is shown a comparison between the average production of all cows and of those which complete a full 273 days test in each unit. This table demonstrates that a much larger gain in production has been recorded for those cows which have completed the full period. Unfortunately, the percentage of cows which complete a full lactation is too small. This indicates a possible way to obtain increased production. It is obvious that a cow will produce more in nine months than it will in eight or seven, or fewer months. Reports from recording officers have shown that by far the greatest proportion of cows which complete a full 273 days test period calve before the end of July. Some idea of the gain may be gauged from an examination of Table 9.

Therefore for the period until and after recording again commences, the farmer should make every effort to keep his cows in milk for a full nine months. It has been demonstrated that he can most easily do this if his cows come in early, that is, before the winter.

It is not easy always to arrange early calving, because of a number of difficulties which may crop up. For example—the cows may fail to become pregnant when mated at the calculated time and when stocking is eventually achieved several months may have passed.

To avoid delay of this type precautions are advisable. The bull should be well cared for and kept apart from the herd at mating time. The cows should be kept in healthy condition, and in order to avoid infections which may prevent their getting in calf, proper attention at calving should be given. The use of pessaries containing a mixture of boracic acid and iodoform immediately a cow cleanses has been proved an excellent precaution.

The Sunny West cups which are given by the directors of the South West Co-operative Dairy Farmers, Ltd., are coveted trophies and have been won this year by the following farmers, according to the zones into which the company's sphere of operations has been divided.

TABLE 10.

"SUNNY WEST" CUPS.

Zone.	Winner.	Unit.	Butter Fat Average.
			lbs.
1	R. L. Maidment	Capel	513·02*
2	H. Eddy	Forest Grove	513·33
3	Fitzpatrick Bros.	Cookernup	529·65
4	J. E. Murray	Manjimup	425·54
5	S. C. Maidment	Balingup	410·56

* Tested for 240 days only.

Other tables which have been of interest to farmers in previous years have been prepared again this year. These show the highest producing cow in each unit, the highest producing herds of over 40, from 20-40, and of under 20 cows, and conclude with the details of the herds in each unit.

TABLE 11.

HIGHEST PRODUCING COW IN EACH UNIT.

Owner.	Unit.	Name of Cow.	Breed.	Test.	Butter Fat.
				%	lbs.
Fitzpatrick Bros. ...	Cookernup ...	Darby ...	Shorthorn x Jersey	4·54	635·55
R. L. Maidment ...	Capel	Gentle ...	do.	6·05	580·76*
G. S. Blaikie ...	Cowaramup ...	Clue ...	Shorthorn ...	3·72	577·42
H. Eddy	Forest Grove ...	Betty ...	Jersey ...	5·38	563·50
Mrs. D. B. Rose ...	Brunswick ...	Tiger ...	do. ...	5·98	529·38
J. E. Murray ...	Manjimup ...	Daisette ...	do. ...	4·84	528·38
Mrs. O. L. Haddow ...	Dardanup ...	Beauty ...	Shorthorn x Jersey	5·33	525·47
McNeil Bros. ...	Pinjarra ...	No. 43 ...	Friesian ...	5·41	501·48
W. B. and R. L. Blaikie	Metricup ...	Star ...	Jersey ...	6·00	480·88
F. Byrd	Harvey ...	Rhoda ...	Friesian ...	3·79	475·23
O. Foan	Donnybrook ...	Poppy ...	Jersey ...	4·95	455·41
S. C. Maidment ...	Balingup ...	Strawberry	Shorthorn x Jersey	4·60	436·81
Farr Bros.	Albany ...	Tiny II. ...	Jersey ...	4·29	432·51
W. K. Barnes ...	Benger ...	Maria ...	Guernsey ...	4·71	411·54*
V. Bunbury ...	Vasse	Pansy ...	Friesian ...	3·41	399·34
G. Scott	Serpentine ...	Elma ...	Friesian ...	3·70	375·68

* Tested for seven months only.

TABLE 12.

LEADING HERDS OF LESS THAN 20 COWS.

Owner.	Unit.	No. of Cows.	Breed.	Butter Fat Average.
				lbs.
G. W. Marston	Brunswick	4	Shorthorn x Friesian	392·11
F. Weels	Dardanup	16	Jersey	371·95
Snedden Bros.	Cowaramup ...	12	do.	360·71
A. Bracknell	Albany	11	Shorthorn	350·40
R. L. Maidment	Capel	14	Shorthorn x Jersey	339·97*
Mrs. O. L. Haddow ...	Dardanup	14	Jersey	339·79
S. R. Aylward	Cookernup	19	do.	337·64
W. E. Bryce	Forest Grove ...	10	Guernsey x Jersey ...	327·97
O. Foan	Donnybrook ...	14	Jersey	327·77
Proctor & Langley ...	Donnybrook ...	18	do.	324·61
R. T. Meade	Balingup	17	Shorthorn x Jersey	304·24
G. Scott	Serpentine	9	Friesian	302·85

* Tested 210 days only.

TABLE 13.

LEADING HERDS OF 20-40 COWS.

Owner.	Unit.	No. of Cows.	Breed.	Butter Fat Average.
				lbs.
H. Eddy	Forest Grove ...	31	Jersey	342·85
A. Miller	Cowaramup ...	27	do.	336·81
T. A. Fenning	Forest Grove ...	32	Jersey x Guernsey	330·14
Fitzpatrick Bros.	Cookernup	38	Shorthorn	326·58
F. Byrd	Harvey	28	Friesian	325·53
F. George	Metricup	21	Shorthorn x Jersey	325·37
M. Brennan	Balingup	20	Jersey	319·29
J. Hartley	Brunswick	35	do.	318·98
Farr Bros.	Albany	27	Shorthorn x Jersey	315·54
J. S. Thompson	Cowaramup ...	21	do. do.	312·79
W. J. Wilson	Forest Grove ...	20	do. do.	309·21
G. S. Blaikie	Cowaramup ...	24	Jersey	308·75
D. Strachan	Dardanup	31	do.	301·37

TABLE 14.

LEADING HERDS OF OVER 40 COWS.

Owner.	Unit.	No. of Cows.	Breed.	Butter Fat Average.
				lbs.
G. W. Payne	Capel	42	Ayrshire	351·93*
J. Salerian	Cookernup	57	Jersey	324·07
S. C. Maidment	Balingup	43	Shorthorn x Jersey	296·95
J. H. Oldfield	Forest Grove ...	51	Guernsey x Jersey	284·60
R. A. Clarke	Brunswick	42	Jersey	278·32
W. Palmer	Cookernup	55	Shorthorn x Jersey	266·06
P. Baruffi	Balingup	42	Jersey	256·26
A. F. Clifton & Co. ...	Brunswick	46	do.	254·41
C. Somerset	Balingup	53	Friesian	249·40
T. Jamieson	Capel	57	Shorthorn x Jersey	238·78*

* Tested 210 days only.

Average Production of all Units.

Particulars of the production of the herds in all units which were under test during 1941-42 are appended hereunder.

Donnybrook "A."	No. of Cows.	Butter Fat Average. lbs.
O. Foan "AL" ...	14	327·77
Proctor Langley "AF"*	18	324·61
A. C. Frost "AC" ...	18	293·16
Herd AA	25	276·08
,, RE	20	271·71
,, RA	13	264·95
,, AG*	17	260·40
,, AK	17	258·40
,, AD	39	237·37
,, AO	35	236·12
,, AA	24	235·70
,, AA*	14	227·76
,, AC	17	224·02
,, RY	16	222·80
,, RY*	22	216·96
,, RL*	12	208·06
,, RX	36	207·60
,, RJ*	17	199·00
,, AC*	17	191·62
,, RK*	24	171·14

* Letter inverted.

Serpentine "B."	No. of Cows.	Butter Fat Average. lbs.
G. Scott "U"	9	302·85
J. Pailthorpe "P" ...	26	272·10
G. Bett "S"	11	258·72
Herd X	16	220·08
,, O	17	218·09
,, F	11	209·60
,, G	21	207·58
,, D*	29	197·18
,, H	41	185·79
,, L	8	170·92
,, C	9	153·00
,, W	38	145·75
,, N	9	141·57

* Letter reversed.

Most herds in this unit tested for seven months only.

Cookernup "C."	No. of Cows.	Butter Fat Average. lbs.
S. R. Aylward "K"* ...	19	337·64
Fitzpatrick Bros. "9C"	38	326·58
J. Salerian "CS" ...	57	324·07
Herd F*	24	294·96
,, R	12	289·71
,, Y	12	285·83
,, E*	28	274·58
,, F	55	266·06
,, Z	18	258·55
,, A4	20	252·10
,, 2C	16	249·52
,, Q*	34	244·28
,, J	25	232·35
,, T	31	231·86
,, A6	31	228·75
,, V	45	217·53
,, A1	27	217·37
,, P	20	197·40
,, A5	40	193·18
,, A3	36	182·16
,, L	29	178·65

* Letter reversed.

Harvey "D."	No. of Cows.	Butter Fat Average. lbs.
F. Byrd "T"	28	325·53
Mrs. A. G. Eckersley "E"	22	271·66
E. Holthouse "AC" ...	13	268·04
Herd BE	19	252·92
,, BG	24	251·80
,, C	26	242·11
,, AA	21	240·47
,, CC	33	239·77
,, B*	30	233·72
,, CB	37	223·23
,, AJ	19	221·73
,, BB	39	218·82
,, BA	31	217·74
,, BC	33	210·80
,, T†	30	207·72
,, BJ	20	204·58
,, CU	33	201·31
,, BH	21	195·90
,, BF	19	192·82
,, NB	31	189·85
,, R*	27	189·55
,, G	24	189·55
,, AD	23	183·12
,, BD	34	155·51
,, NT	22	114·36

* Letter reversed. † Letter inverted.

Average Production of all Units—continued.

Brunswick "E."	No. of Cows.	Butter Fat Average. lbs.
G. W. Marston "E" * ...	4	392·11
J. Hartley "M" ...	35	318·98
R. A. Clarke "C" ...	42	278·32
Herd 9 *	15	259·71
„ Q	46	254·41
„ L*	39	250·14
„ A†	29	240·31
„ Q*	19	235·92
„ F	31	231·92
„ B*	56	231·16
„ T†	19	228·49
„ S*	20	222·77
„ C	44	213·10
„ X	51	197·58
„ T	32	188·82
„ H	32	186·35
„ U	55	180·91
„ K*	32	163·98

* Letter reversed. † Letter inverted.

Dardanup "F."	No. of Cows.	Butter Fat Average. lbs.
F. Wells "Y" * ...	16	371·95
O. L. Haddow "AB" *	14	339·78
D. Strachan "C" ...	31	301·37
Herd AN*	24	272·52
„ A	27	255·56
„ I	16	253·28
„ C*	29	246·95
„ FF	15	244·08
„ T*	16	239·82
„ AD*	41	236·00
„ TT	35	228·30
„ A*	23	224·37
„ AU*	25	222·51
„ AW	81	198·18
„ D	34	191·61
„ AW*	25	167·30
„ CH	39	163·61
„ WF	34	146·04
„ AC*	28	120·00

* Letter inverted.

Capel "G."	No. of Cows.	Butter Fat Average. lbs.
G. W. Payne "X" ...	42	351·93
R. L. Maidment "W" ...	14	339·97
T. Jamieson "S" ...	57	238·78
Herd N	35	235·03
„	24	214·72
„ Q	34	213·95
„ A	49	212·56
„ V*	15	165·19
„ R	41	135·99
„ U*	44	125·28
„ VF	27	95·93
„ Z	52	90·98

* Letter inverted.

Herds in this unit tested seven months only.

Balingup "H."	No. of Cows.	Butter Fat Average. lbs.
M. Brennan "R" ...	20	319·29
A. T. Meade "Y" ...	17	304·24
S. C. Maidment "S" ...	43	296·95
Herd G*	40	274·59
„ N	29	271·53
„ Q	18	270·41
„ R*	26	266·76
„ A†	33	263·87
„ B*	30	260·16
„ D*	18	257·94
„ F*	42	256·26
„ K*	53	249·40
„ H9	19	245·26
„ C	48	240·17
„ F	14	219·40
„ T†	30	157·02
„ E	Tested less than 100 days.	
„ P	do.	

* Letter reversed. † Letter inverted.

Average Production of all Units—continued.

Forest Grove "I."	No. of Cows.	Butter Fat Average. lbs.
H. Eddy "U"	31	342·85
T. A. Fenning "N"	32	330·14
W. E. Bryce "B"	10	327·97
Herd W	20	309·21
„ D	51	284·60
„ M	29	284·16
„ P	50	239·70
„ T†	26	226·65
„ Y	12	220·88
„ J	22	218·77
„ Y†	19	212·04
„ L†	31	207·10
„ V	31	205·47
„ E	30	204·17
„ S	41	197·60
„ Z	27	189·52
„ T	16	182·45
„ H	37	171·31
„ K	15	157·89
„ Q	16	151·08
„ K*	26	124·19

* Letter reversed. † Letter inverted.

Vasse "L."	No. of Cows.	Butter Fat Average. lbs.
V. Bunbury "Y"	20	289·67
H. W. Semmens "X"	19	265·80
D. H. Bell "Z"	33	244·61
Herd P*	18	240·50
„ U†	21	221·29
„ N	22	207·76
„ D	19	198·34
„ T	11	193·48
„ R†	30	173·50
„ A	29	170·10
„ VV	29	145·54
„ LO	26	135·00
„ V	12	119·81
„ F	38	107·97
„ S	19	107·89
„ J	10	102·89

* Letter reversed. † Letter lying on side.
Most herds tested for seven months only.

Manjimup "M."	No. of Cows.	Butter Fat Average. lbs.
J. O. Shepherd "H"	18	295·85
F. S. Little "L"	14	290·26
M. Kilrain "C"	27	260·70
Herd E	20	251·69
„ N	19	244·46
„ A	30	243·87
„ B*	28	243·74
„ B	30	227·24
„ V	15	222·36
„ AB	26	221·93
„ L*	19	220·94
„ U	21	219·68
„ J†	21	214·10
„ M	42	209·21
„ O	66	202·50
„ K†	19	188·78
„ P	49	181·13
„ Y	30	175·47
„ T	31	172·35
„ ZR	21	168·84
„ F*	26	168·24
„ A‡	40	164·51

* Letter reversed. † Letter lying on side. ‡ Letter inverted.

Benger "O."	No. of Cows.	Butter Fat Average. lbs.
W. K. Barnes "G"	28	240·55
W. S. Patridge "P"	46	214·97
G. M. Dempster "E"	58	193·75
Herd J	66	192·49
„ Y	16	173·30
„ W	28	170·95
„ S	43	162·40
„ AB	47	141·85
„ C	37	138·70
„ AD	16	132·61
„ AC	13	127·00
„ AF	21	124·01

Herds in this unit tested seven months only.

Average Production of all Units—continued.

Pinjarra "P."	No. of Cows.	Butter Fat Average.
		lbs.
Caratti Bros. "C" ...	24	284·74
F. L. Phillips "B" ...	12	279·59
D. G. Spark "G" ...	34	250·40
Herd X	11	249·32
„ J	18	245·76
„ F*	35	245·48
„ B†	17	229·26
„ E†	33	224·60
„ A	49	222·56
„ F	14	215·33
„ V	10	203·62
„ D†	23	194·42
„ D	9	187·42
„ I	3	174·07
„ K†	10	144·92
„ H	55	117·71
„ L	31	115·01
„ K	24	110·92
„ M	21	77·92

* Letter reversed. † Letter inverted.

Albany "S."	No. of Cows.	Butter Fat Average.
		lbs.
A. Bracknell "A"* ...	11	350·40
Farr Bros. "B"* ...	27	315·54
L. Jordan "Q"* ...	16	295·43
Herd F*	14	284·04
„ L	27	276·08
„ X	25	241·55
„ F	15	237·36
„ I*	24	230·27
„ B	17	229·51
„ H	11	221·27
„ U*	18	219·23
„ M*	28	217·75
„ V*	49	216·43
„ G*	17	204·57
„ N	18	202·96
„ K*	19	201·96
„ D*	34	194·31
„ R*	21	190·68
„ O	13	188·59
„ T	22	187·52
„ J	7	183·52
„ E	23	176·46
„ P	17	169·23

* Letter inverted.

Metricup "U."	No. of Cows.	Butter Fat Average.
		lbs.
F. George "KQ" ...	21	325·37
W. B. and R. L. Blaikie "A"	30	281·91
W. J. Burt "H" ...	19	270·90
Herd BU	16	264·64
„ C*	12	249·44
„ KL*	10	245·17
„ KA*	16	242·95
„ KP	22	242·89
„ K†	14	236·14
„ A*	11	235·56
„ N	37	228·26
„ G	16	217·52
„ P*	18	217·40
„ AF	19	214·93
„ AU	18	208·52
„ Y	25	203·98
„ AA	15	196·19
„ AB	24	192·96
„ Y*	15	189·23
„ AG	12	188·20
„ D†	10	183·16
„ AC	10	172·33
„ D	18	170·84
„ J	11	161·94

* Letter inverted. † Letter reversed.

Cowaramup "X."	No. of Cows.	Butter Fat Average.
		lbs.
Snedden Bros. "KP"*	12	360·71
A. Miller "KM" ...	28	336·81
J. S. Thompson "U" ...	21	312·79
Herd L	24	308·75
„ KF*	15	298·56
„ IJ*	24	273·28
„ KI	23	266·19
„ IBB	21	260·98
„ IM	13	246·90
„ IV	11	243·66
„ A*	20	239·77
„ IK*	24	238·39
„ Q	22	229·74
„ IZ	15	223·82
„ S	16	213·76
„ IQ	25	204·77
„ G*	10	168·68
„ B*	30	161·93

* Letter inverted.

Notching of Dormant Buds on Apple Trees.

A. T. GULVIN, Horticultural Instructor.

Since the adoption of the "Wickens" method of pruning whereby the leaders are not topped, and to a lesser extent under the older orthodox method, lower buds on the leaders of young Granny Smith apple trees particularly, but also on other varieties, frequently fail to burst. Such buds will remain dormant for many years if allowed to go unattended. The result is the presence along the leaders of long bare spaces where there should be laterals, fruit spurs, and, what is perhaps more important under the new system, subleaders.

In order to make these buds burst, it is necessary to resort to "notching." This consists of cutting a notch about one-quarter to three-eighths of an inch above the bud. The notch is about one-sixteenth to one-eighth of an inch in width, and is cut through the bark and the cambium layer and extends to each side of the bud.

In an effort to ascertain the most suitable time to carry out this operation, an experiment was conducted with some Granny Smith trees at Kalgan River. The leaders of these trees had not been topped for a number of years. The wood on which the notching was done was about three years old.

The operation was done on two trees on each occasion. Intervals of about two weeks elapsed between the notching of each set of two trees.

The times of notching, together with the results obtained are shown in the table attached:—

OBSERVATIONS ON BUDS NOTCHED.

Date of Notching.	Date of Observation.			
	September 25th.	October 8th.	October 20th (Spur Burst).	December 6th.
August 13th ...	Buds well shot	Buds well shot	...	All buds made shoots up to 12 in. long.
August 28th ...	No effect	Buds well shot	...	Mostly made shoots 6 in. to 12 in. long.
September 8th ...	No effect	Buds moving	...	Half buds made shoots up to 9 in.; remainder spurs.
September 25th	...	...	Buds moving slightly	Mostly made spurs; few shoots up to 4 in.
October 8th ...	...	...	...	All made spurs.
October 20th ...	...	...	...	Mostly made spurs; few shoots up to 6 in.
November 6th ...	...	...	...	All made shoots up to 3 in.

Observations at the end of the growing season showed that the situation had varied little from that obtaining on December 6th, the main difference being that shoots on the trees notched on November 6th had grown to about six inches in length.

The results of the trial which appear in the above table have shown the earlier August notching to have been most effective. The October operations were without effect. Buds were induced to make shoots by notching in November.

It is most likely that the best time for this work will vary somewhat from season to season, and it is hoped that further data on this point will be obtained. Previous trials have shown that no effect follows notching during the normal pruning period of June and July. The data reported above suggests that most effect will follow notching done during the mid-August to mid-September period.

Early Subterranean Clover Pastures.

FOR AREAS OF MEDIUM RAINFALL.

A. B. ADAMS.

In those districts that have a medium rainfall over a comparatively short period such as the Northam and York districts, only early flowering varieties of subterranean clover are suited to the conditions. There are several varieties to be found in the neighbourhood of York and Northam that satisfy this condition, and have survived since their accidental introduction. Incidentally, there is no record of the date of this occurrence except that they must have been there for many years previous to 1930, when they were reported in this Journal. When on suitable soil they survived without care and practically unobserved.

The attempt to introduce into these districts the Mt. Barker variety, which is comparatively late in flowering, was a failure, not because it failed to set seed, but because it failed to bury sufficient seed.

All varieties of subterranean clover need soil that is moist on the surface if they are to bury seed, and failure to bury it means that sheep or rabbits, during the summer, will consume most of the seed that is unburied. Hence the failure to re-establish itself in following seasons.

The importance of using an early variety is now appreciated by those members of the farming community who are interested in developing a pasture that has a greater stock-carrying capacity for a longer period than the ordinary volunteer silver grass—cape weed—annual clover pasture that follows the cereal crop.

Now that the growth of wheat for sale is restricted and the market for other cereals is limited and hence they cannot be grown in increased quantities for profitable sale, it is certain that much land will be left out in pasture owing to the impossibility of cropping it profitably. This being so, why not establish an improved pasture that will carry more stock for a longer period and carry them better than land that has been allowed to "tumble down" to a pasture of inferior grasses and weeds.

The reasons why subterranean clover is better than many of the common annual clovers and trefoils may be stated thus:—

1. It makes earlier feed than most clovers except burr trefoil which is, if anything, earlier.

2. It has a prolonged flowering period and continues to make fresh runners which continue growth until killed by the drying up of the soil. The latter growth, therefore, is a natural hay. In contrast, most of the annuals, e.g., cluster or hop clover, which are valuable when green, flower, set seed and then cease growth, which means that as summer feed they are comparatively mature straw and seed. The straw has little nutritive value and the seed is so small that it escapes digestion in the sheep's stomach. An exception to this statement is again the burr trefoil, which has comparatively large seed.

3. The burrs do not cling closely to the wool as do the burrs of burr trefoil or the seeds of barley grass and wild geranium.

4. With proper fertilisation it will thrive on comparatively light and poor soils.

5. If a variety suited to the conditions is grown it will bury a large quantity of seed, making renewal comparatively certain in spite of heavy stocking and rabbits.

6. It will build up the soil in organic matter, thus preventing soil erosion and making it better for cereal cropping when that is resumed in the future.

For the farmer who has had little experience in the growing of subterranean clover, a few suggestions may prove of value.

Establishment.

It may be established by surface sowing on new land as has been done so successfully in the wetter districts, but with our present difficulties it is anticipated that most growers will wish to develop pasture on land that has been under crop.

From the writer's experience one of the best methods is to burn the stubble of a crop that has been stripped for grain, burning as late in the season as is likely to give a good burn. If one can wait until an early rain has germinated the weed seeds, all the better. Whether or not this is possible depends on the season and the amount of straw.

After the first rain, give a shallow cultivation with a rigid tyne or spring tooth cultivator, and seed in May with a suitable variety of oats and 2 lbs. to 4 lbs. of subterranean clover seed.

The oats sown with the crop are to give a return for the first season's work, and may be fed off, cut for hay or stripped.

The reason for the variation in rate of clover seed is because of a possible steep rise in the price of seed. The writer has had very good results from 2 lbs. of seed per acre, and has seen a good result from as little as ½ lb. per acre. If seed is cheap there is little need to cut down the quantity per acre, but if it is scarce and dear it may be both sound practice and patriotic to reduce the amount per acre.

If a special grass seeding attachment is not available, mix the subterranean clover seed with the super, and to avoid risk of injury to the seed, mix it immediately before sowing. It is quite possible to mix it in the seed box of the drill.

Do not set the drill any deeper than will serve to cover the oats. The shallow first cultivation and shallow drilling serve two objects, viz., to maintain a firm seed bed and to avoid burying the clover seed too deeply.

Those who are not familiar with the growing of subterranean clover should realise that the main object of the first season is to produce a good setting of seed; hence, if the oats are grazed, stock should be kept off in the spring to allow of seed setting. The stubble may be heavily grazed throughout the summer if desired.

Management the Second Season.

Keep sheep out of the paddock following the first rain until the clover plants have made several leaves. Sheep will nip off the seed leaves, and any plant so treated is killed, hence the need to keep them out until the plants are a fair size. Topdressing is advisable, but need not be heavy as the plants are comparatively sparse the season after seeding. Sixty pounds of superphosphate per acre should be ample. Probably the clover plants in the line of the previous year's drilling would not need more super, but the plants between the drill rows usually need it.

The pasture may be grazed fairly closely during the winter, but again it is advisable to graze lightly in the spring to get a good setting of seed. This light stocking is no loss because as pointed out above, when subterranean clover dries off it forms a natural hay, hence the growth not consumed in the spring makes good summer feed.

If in the early part of the second year, or for that matter in any year, there is a heavy weed growth of such plants as cape weed, the paddock should be stocked heavily, if this is practicable, to eat off the weeds quickly. This procedure gives the clover a chance to grow, as it is no longer smothered with weeds.

Management in Succeeding Years.

Consists mainly in topdressing with superphosphate and management of the stock. Grazing should be sufficient to keep down weed growth without overgrazing the clover.

In normal times the topdressing should vary with the growth of clover and the stocking, e.g., 60 lbs. of superphosphate is sufficient on a thin stand as stated above. When the clover thickens up and is capable of carrying say three ewes and lambs to the acre, for a good part of the growing period, it is profitable in normal times to use up to three times that amount. The heavy dressing may not cause a noticeable difference in growth if the paddock is not grazed, but the plants will stand up better to grazing and will produce more feed of greater nutritive value.

Today, with limited supplies of super, probably the best advice is to use the least amount that will show a beneficial effect so that the small amount of super available may be spread over the largest possible area.

It is impossible to lay down an exact amount for all circumstances, therefore the farmer should carry out experiments for himself. The simplest experiment for the farmer is to apply the smallest amount that he considers will give a result over most of his pasture; leave occasional strips without any fertiliser for comparison and fertilise still other strips with say one-third and two-thirds of the usual dressing.

If he does this he will have something definite to work on in succeeding years.

The growth of subterranean clover usually increases soil fertility, which in turn encourages the growth of non-leguminous plants such as silver grass and cape weed. Before the stage of high soil fertility is reached, and while subterranean clover forms the major part of the plant cover, if grazed with sheep they will tend to keep down this miscellaneous growth by eating it as a change from the more plentiful subterranean clover. When the reverse position arises and the clover plants are in the minority, the tables are turned and there is a tendency for the sheep to neglect the miscellaneous plants and to graze as much or more of the clover.

At this stage growers are apt to think that the clover is stalling, whereas it is really a natural rotation. It can be tackled, with reasonable hope of increasing the percentage of clover, in one of two ways:

The one is to mow the growth for hay, preferably while the majority of the annual grasses are in flower. In many cases the next year's growth on the mown area is mainly subterranean clover.

The other method is to cultivate with the first rains, preferably with a rigid tyne cultivator and then drill in a cereal crop of oats or wheat for grain or hay. This cashes in on the accumulated fertility, especially the nitrogen, and so the clover again has the advantage the following year.

For the farmer whose main interest is stock, this method has the advantage that cereals, in the districts that are the subject of these notes, usually return the best crop in a dry season, whereas in a wet year the best clover hay crops are obtainable. If, therefore, one cultivates a cereal into part of the old pasture and saves the other part for hay, a good hay crop either cereal or clover is almost certain.

Establishment of Subterranean Clover on existing inferior pasture.

This can be readily accomplished without preliminary cultivation. If the existing pasture consists of annual clovers, etc., the subterranean clover seed can be mixed with superphosphate and drilled in or broadcast, with a broadcaster or by hand. Drilling is usually the most satisfactory as the surface is scratched sufficiently to cover the seed. Nevertheless quite good stands have resulted from broadcasting the seed and fertiliser where the dry grass, etc., provides more shelter.

Establishment of Subterranean Clover on recently cleared country.

The present time, with very limited supplies of phosphate, is scarcely opportune for developing new areas. The following notes are appended in the hope that happier times will soon enable us to get on with developmental projects.

I wish to place it on record that pastures can be established by surface sowing methods, often called sowing on the burn, as successfully in areas of medium, as in those of heavy rainfall.

The type of country now to be considered is that which has not carried any pasture in the shape of grasses and minor clovers. The best method varies with the conditions, which is a truism in all agricultural processes.

If the ground is cleared sufficiently to allow the use of machinery, then it is best to take a cereal crop and sow the clover with it as recommended above. As

the condition with which we are now dealing presupposes an absence of annual clovers, it will be necessary to inoculate the clover seed with the correct strain of bacteria which can be obtained from the Department of Agriculture. From experiments in the mixing of inoculated seed with superphosphate and basic superphosphate (see Departmental Bulletin No. 584), it was found that superphosphate caused little or no injury if sowing took place immediately after mixing, but delayed sowing caused definite injury. Mixing with basic superphosphate caused practically no injury to seed or bacteria even when there was considerable delay between mixing and sowing.

When conditions do not allow of taking a crop due to insufficiently cleared, rocky or very broken land, a different angle of approach is indicated. Instead of sowing inoculated clover seed on the bare surface, a procedure unlikely to be successful, establish first a silver grass—minor clover pasture. When this is established then introduce the subterranean clover.

To establish the silver grass and minor clovers, sow either the bottoms of meadow hay stacks containing a good many mature plants of the desired species, or sweep up an area where there has been a thick stand of them and sow the sweepings, fertilising with a light dressing of super. This method will provide pasturage which should at least pay the cost of treatment and will prepare the way for a subterranean clover pasture.

SUMMARY.

In areas of medium rainfall the early varieties of subterranean clover are necessary.

The greater value of subterranean clover as compared with the ordinary volunteer pasture is indicated.

Methods of establishment and after management are discussed.

Yellow Burweed.

(*Amsinckia hispida* (Ruix et Pav.) Johnson.)

C. A. GARDNER,
Government Botanist.

Yellow Burweed is an annual plant native to Chili, but already naturalised in the Mediterranean countries, and in the Eastern States of Australia. It belongs to the Borage family (Borraginaceae), a family producing many horticultural species, such as the Forget-me-not, and many plants unpalatable to stock, such as Paterson's Curse, the Corn Gromwell, etc., and few, if any, that can be regarded as of definite value to the agriculturist or pastoralist. Characteristic of the family are the stiff hairs which clothe the leaves and stems, which in themselves make them unattractive

to grazing animals, and the fruit which consists of four "nutlets"—seed-like bodies which are thick and hard, and usually retain their viability for several years. Another characteristic by which many Borraginaceous plants may be recognised, is the inflorescence, or the disposition of the flowers and flower-stalks. The individual flowers in this family are usually arranged on one side of an axis which is rolled or revolute when young, lengthening and straightening out as the flowers develop.

This undesirable weed first made its appearance in Western Australia in 1936, when it was received from the Tammin district. Still more recently it appeared at Crawley, where it is now under control, and during the past season it made its appearance in several linseed crops, especially in the Northam and York districts. Farmers who recognise the weed are advised to eradicate the plants immediately.

One of the most objectionable characters of the weed is its prolific seed production, and it should be noticed that the lower flowers of the spike have already produced seeds long before the uppermost flowers have expanded.

The plant when young has something the appearance of Paterson's Curse (*Echium plantagineum*), but the habit is more erect, and the leaves narrower, and the simple stem does not usually branch except in the upper parts, and frequently it is unbranched. It attains a height of about two feet, sometimes three feet; the stem-leaves are shorter and broader than the basal leaves, and all, as well as the stems are coarsely hairy, the hairs being almost bristly. The branches bearing the flowers are curled, and the flowers themselves are a deep yellow, and bear five darker orange-red spots in the throat. The calyx is coarsely hairy, and the sepals 5. The stamens are five in number, and do not extend beyond the throat of the corolla. The "seeds" are pale-coloured, and much wrinkled.

There are three very closely related species of Amsinckia which might be regarded as the one species, since the differences between them are so slight. Two are native to California—*A. intermedia* and *A. lycopsoides,* while the third (*A. hispida*) is a native of Chili. *Amsinckia intermedia,* as its name indicates, is intermediate between the two, and almost forms a connecting link between them. This intermediate species has been shown to be poisonous to stock. Tests made on the seeds of this plant by E. C. McCulloch, proved that the ingestion of the seeds caused enzoötic hepatic cirrhosis, known as "Walking disease" of horses, and "Hard liver disease" of pigs and cattle. Sheep appear to be immune, or at least highly resistant. This, by the way, is the first occasion in which any Borraginaceous plant has been proved to be toxic.

The weed is a tap-rooted annual, and the plants can be pulled easily. Badly infested areas should be cultivated or harrowed in the early winter, to destroy the weed seedlings. It is of importance that the weed should not be allowed to form seeds. Seed formation commences at the base of the flower-spike before the upper flowers have expanded, and it is therefore advisable to destroy the plants before flowering, or not later than the time when flowering first commences.

It is stated in California, that where the stems of *Amsinckia intermedia* grow rankly, and are allowed to mature, they become very dry and brittle, and are then easily fired, so that in the grainfields of the San Joaquin and Sacramento valleys, a frequent source of fire loss is due to these stalks with their tinder-like leaves.

The "seeds" of Amsinckia are usually distributed as impurities in seed. These seeds somewhat resemble grains of wheat in size and colour, and are easily overlooked.

Yellow Burweed is a proclaimed noxious weed for the State of Western Australia.

Explanation of Plate.

YELLOW BURWEED.

(Amsinckia hispida (Ruiz et Pav.) Johnson.)

A. Habit. B. Stem leaf. C. Flower (much enlarged). D. The same showing two stamens and pistill. E. Nutlet or "seed."

Northam, August, 1941.

The Official Australian Pure Bred Dairy Cattle Production Recording Scheme (1941-1942).

The following two cows were inadvertently omitted from Results published in the September Journal.

COWS 4 YEARS OLD AND UNDER 4½ YEARS.

Name of Cow.	Breed.	Date of Birth.	Date of Entry to Test.	No. of Days in Test.	Weight of Milk Last Day of Test.	Weight of Milk for Period.	Average Test.	Butter Fat for Period.	Owner.	Sire.
					lb.	lb.	%	lb.		
Glanavon Doris 5th	A.I.S.	5–12–36	31–12–40	273	51	13,443	4·62	620·66	D. Bevan & Sons	Blacklands Jean's Supreme (1871)
Glanavon Lulu ...	do.	25–10–36	15–4–41	273	32	12,306	4·48	551·47	D. Bevan & Sons	Blacklands Jean's Supreme (1871)

Both the above exceeded the State Record for Junior Four-year-old (A.I.S.) Cows previously held by Mr. A. E. Grant's Telyarup Duchess with 522·84 lbs. Butter Fat in 273 days.

As both Glanavon Doris 5th and Glanavon Lulu are by Blacklands Jean's Supreme, the record of this Bull, published in the September Journal is amended, as follows :—

Blacklands Jean's Supreme ... ... Sire—Fussy's Monarch of Hillview.
Dam—Jean 7th of Blacklands.

10 daughters averaged 461·61 lbs. Butter Fat without, and 511·62 lbs. Butter Fat with Age Allowances.

6 highest producing daughters averaged 543·45 lbs. Butter Fat without, and 563·77 lbs. Butter Fat with Age Allowances.

By Authority: ROBERT H. MILLER, Government Printer, Perth.